2005 Tri-Service Infrastructure Systems Conference & Exhibition

St. Louis, MO
"Re-Energizing Engineering Excellence"

2-4 August 2005

Agenda

Panel*:* The Future of Engineering and Construction

- LTG Carl A. Strock, Commander, USACE
- Dr. James Wright, Chief Engineer, NAVFAC

Panel*:* USACE Engineering and Construction

- Dr. Michael J. O'Connor, Director, R&D

Panel*:* Navy General Session

- Mr. Steve Geusic, Engineering Criteria & Programs NAVFAC Atlantic

Introduction to Multi-Disciplinary Tracks, by Mr. Gregory W. Hughes
Engineering Circular: Engineering Reliability Guidance for Existing USACE Civil Works Infrastructure, by Mr. David M. Schaaf, PE, LRD Regional Technical Specialist, Navigation Engineering Louisville District
MILCON S&A Account Study, by Mr. J. Joseph Tyler, PE, Chief, Programs Integration Division, Directorate of Military Programs HQUSACE
Financial Justification on Bentley Enterprise License Agreement (ELA)

Track 1

- The Chicago Shoreline Storm Damage Reduction Project, by Andrew Benziger
- Protecting the NJ Coast Using Large Stone Seawalls, by Cameron Chasten
- Cascade: An Integrated Coastal Regional Model for Decision Support and Engineering Design, by Nicholas C. Kraus and Kenneth J. Connell
- Modeling Sediment Transport Along the Upper Texas Coast, by David B. King Jr., Jeffery P. Waters and William R. Curtis
- Sediment Compatibility for Beach Nourishment in North Carolina, by Gregory L. Williams
- Evaluating Beachfill Project Performance in the USACE Philadelphia District, by Monica Chasten and Harry Friebel
- US Army Corps of Engineers' National Coastal Mapping Program, by Jennifer Wozencraft
- Flood Damage Reduction Project Using Structural and Non-Structural Measures, by Stacey Underwood
- Shore Protection Project Performance Improvement Initiative (S3P2I), by Susan Durden
- Hurricane Isabel Post-Storm Assessment, by Jane Jablonski
- US Army Corps of Engineers Response to the Hurricanes of 2004, by Rick McMillen and Daniel R. Haubner
- Increased Bed Erosion Due to Increased Bed Erosion Due to Ice, by Decker B. Hains, John I. Remus, and Leonard J. Zabilansky
- Mississippi Valley Division, by James D. Gutshall
- Impacts to Ice Regime Resulting from Removal of Milltown Dam, Clark Fork River, Montana, by Andrew M. Tuthill and Kathleen D. White, and Lynn A. Daniels
- Carroll Island Micromodel Study: River Miles 273.0-263.0, by Jasen Brown
- Monitoring the Effects of Sedimentation from Mount St. Helens, by Alan Donner, Patrick O'Brien and David Biedenharn
  Watershed Approach to Stream Stability and Benefits Related to the Reduction of Nutrients, by John B. Smith
- A Lake Tap for Water Temperature Control Tower Construction at Cougar Dam, Oregon, by Stephen Schlenker, Nathan Higa and Brad Bird
- San Francisco Bay Mercury TMDL – Implications for Constructed Wetlands, by Herbert Fredrickson, Elly Best and Dave Soballe
- Abandoned Mine Lands: Eastern and Western Perspectives, by Kate White and Kim Mulhern
  Translating the Hydrologic Tower of Babel, byDan Crawford
- Demonstrating Innovative River Restoration Technologies: Truckee River, Nevada, by Chris Dunn
- System-Wide Water Resource Management – Tools of the Trade

Track 2

- Ecological and Engineering Considerations for Dam Decommissioning, Retrofits, and Reoperations, by Jock Conyngham
- Hydraulic Design of tidegates and other Water Control structures for Ecosystem Restoration projects on the Columbia River estuary, by Patrick S. O'Brien
- Surface Bypass & Removable Spillway Weirs, by Lynn Reese
- Impacts of using a spillway for juvenile fish passage on typical design criteria, by Bob Buchholz
- Howard Hanson Dam: Hydraulic Design of Juvenile Fish Passage Facility in Reservoir with Wide Pool Fluctuation, by Dennis Mekkers and Daniel M. Katz
- Current Research in Fate Current Research in Fate & Transport of Chemical and Biological Contaminants in Water Distribution Systems, by Vincent F. Hock
- Regional Modeling Requirements, by Maged Hussein
- Tools for Wetlands Permit Evaluation: Modeling Groundwater and Surface Water Interaction, by Cary Talbot
- Ecosystem Restoration for Fish and Wildlife Habitat on the UMRS, by Jon Hendrickson
- Missouri River Shallow Water Habitat Creation, by Dan Pridal
- Aquatic Habitat Restoration in the Lower Missouri River, by Chance Bitner
- Transition to an Oracle Based Data System (Corps Water Management System, CWMS), by Joel Asunskis
- RiverGages.com: The Mississippi Valley Division Water Control Website, by Rich Engstrom
- HEC-ResSim 3.0: Enhancements and New Capabilities, by Fauwaz Hanbali
- Hurricane Season 2004 – Not to Be Forgotten, by Jacob Davis
- Re-Evaluation of a Flood Control Project, by Ferris W. Chamberlin
- Helmand Valley Water Management Plan, by Jason Needham
- A New Approach to Water Management Decision Making, by James D. Barton
- Developing Reservoir Operational Plans to Manage Erosion and Sedimentation during Construction – Willamette Temperature
- Control, Cougar Reservoir 2002-2005, by Patrick S. O'Brien
- Improved Water Supply Forecasts for the Kootenay Basin, by Randal T. Wortman
- ResSIM Model Development for Columbia River System, by Arun Mylvahanan
- Prescriptive Reservoir Modeling and the ROPE, by Jason Needham
- Missouri River Basin Water Management, by Larry Murphy

Track 3

- Corps Involvement in FEMA's Map Modernization Program, by Kate White, John Hunter and Mark Flick
- Innovative Approximate Study Method for FEMA Map Moderniation Program , by John Hunter
- Flood Fighting Structures Demonstration and Evaluation Program (FFSD), by Fred Pinkard
- Integrating Climate Dynamics Into Water Resources Planning and Management, by Kate White
- Hydrologic and Hydraulic Contributions to Risk and Uncertainty Propagation Studies, by Robert Moyer
- Uncertainty Analysis: Parameter Estimation, by Jackie P. Hallberg
- Geomorphology Study of the Middle Mississippi River, by Eddie Brauer
- Bank Erosion and Morphology of the Kaskaskia River, by Michael T. Rodgers
- Degradation of the Kansas City Reach of the Missouri River, by Alan Tool
- Sediment Impact Assessment Model (SIAM), by David S. Biedenharn and Meg Jonas
- Mississippi River Sedimentation Study, by Basil Arthur
- Sediment Model of Rivers, by Charlie Berger
- East Grand Forks, MN and Grand Forks, ND Local Flood Damage Reduction Project, by Michael Lesher
- Hydrologic and Hydraulic Analyses, by Thomas R. Brown
- Hydrologic and Hydraulic Modeling of the Mccook and Thornton Tunnel and Reservoir Plans, by David Kiel
- Ala Wai Canal Project, by Lynnette F. Schaper
- Missouri River Geospatial Decision Support Framework, by Bryan Baker and Martha Bullock
- Systemic Analysis of the Mississippi & Illinois Rivers Upper Mississippi River Comprehensive Plan, by Dennis L. Stephens

Section 227: National Shoreline Erosion Control Demonstration and Development Program Annual Workshop

- Workshop Objectives
- Section 227: Oil Piers, Ventura County, CA, by Heather Schlosser
- An Evaluation of Performance Measures for Prefabricated Submerged Concrete Breakwaters: Section 227 Cape May Point, New Jersey Demonstration Project, by Donald K Stauble, J.B. Smith and Randall A. Wise
- Bluff Stabilization along Lake Michigan, using Active and Passive Dewatering Techniques, by Rennie Kaunda, Eileen Glynn, Ron Chase, Alan Kehew, Amanda Brotz and Jim Selegean
- Storm Damage at Cape Lookout
- Branchbox Breakwater Design at Pickleweed Trail, Martinez, CA
- Section 227: Miami, FL
- Section 227: Sheldon Marsh Nature Preserve
- Section 227: Seabrook, New Hampshire
- Jefferson County, TX – Low Volume Beach Fill
- Sacred Falls, Oahsacred Falls, Oahu Section 227 Demonstration Project

Track 4

- Fern Ridge LakFern Ridge Lake Hydrologic Aspects of Operation during Failure, by Bruce J Duffe
- A Dam Safety Study Involving Cascading Dam Failures, by Gordon Lance
- Spillway Adequacy Analysis of Rough River Lake Louisville District, by Richard Pruitt
- Water Management in Iraq: Capability and Marsh Restoration, by Fauwaz Hanbali
- Iraq Ministry of Water Resources Capacity Building, by Michael J. Bishop, John W. Hunter, Jeffrey D. Jorgeson, Matthew M. McPherson, Edwin A. Theriot, Jerry W. Webb, Kathleen D. White, and Steven C. Wilhelms

- HEC Support of the CMEP Program, by Mark Jensen
- Geospatial Integration of Hydrology & Hydraulics Tools for Multi-Purpose, Multi-Agency Decision Support, by Timothy Pangburn, Joel Schlagel, Martha Bullock, Michael Smith, and Bryan Baker
- GIS & Surveying to Support FEMA Map Modernization and Example Bridge Report, by Mark Flick
- High Resolution Bathymetry and Fly-Through Visualization, by Paul Clouse
- Using GIS and HEC-RAS for Flood Emergency Plans, by Stephen Stello
- High Resolution Visualizations of Multibeam Data of the Lower Mississippi River, by Tom Tobin and Heath Jones
- System Wide Water Resources Program Unifying Technologies Geospatial Applications, by Andrew J. Bruzewicz
- Raystown Plate Locations
- Hydrologic Engineering Center: HEC–HMS Version 3.0 New Features, by Jeff Harris
- SEEP2D & GMS: Simple Tools for Solving a Variety of Seepage Problems, by Clarissa Hansen, Fred Tracy, Eileen Glynn, Cary Talbot and Earl Edris
- Sediment and Water Quality in HEC-RAS, by Mark Jensen
- Advances to the GSSHA Model, by Aaron Byrd and Cary Talbot
- Watershed Analysis Tool: HEC-WAT Program, by Chris Dunn
- Little Calumet River UnsteadLittle Calumet River Unsteady Flow Model Conversion UNET to HEC-RAS, by Rick D. Ackerson
  Kansas River Basin Model, by Edward Parker
- Design Guidance for Breakup Ice Control Structures, by Andrew M. Tuthill
- Computational Hydraulic Model of the Lower Monumental Dam Forebay, by Richard Stockstill, Charlie Berger, John Hite, Alex Carrillo, and Jane Vaughan
- Use of Regularization as a Method for Watershed Model Calibration, by Brian Skahill
- Demonstration Program Urban Flooding and Channel Restoration in Arid and Semi-Arid Regions (UFDP), by Joan Pope, Jack Davis, Ed Sing, John Warwick, Meg Jonas

Track 5

- Walla Walla District Northwestern Division, by Robert Berger
- Best Practices for Conduits through Embankment Dams, by Chuck R. Cooper
- Design, Construction Design, Construction and Seepage at Prado Dam, by Douglas E. Chitwood
- 2-D Liquefaction Evaluation with Q4Mesh, by David C. Serafini
- Unlined Spillway Erosion Risk Assessment, by Johannes Wibowo, Don Yule, Evelyn Villanueva and Darrel Temple
- Seismic Remediation of the Clemson Upper and Lower Diversion Dams; Evaluation, Conceptual Design and Design, by Lee Wooten and Ben Foreman
- Seismic Remediation of the Clemson Upper and Lower Diversion Dams; Deep Soil Mix Construction, by Lee Wooten and Ben Foreman
- Historical Changes in the State of the Art of Seismic Engineering and Effects of those changes on the Seismic Response Studies of Large Embankment Dams, by Sam Stacy
- Iwakuni Runway Relocation Project, by Vincent R. Donnally
- Internal Erosion & Piping at Fern Ridge Dam, by Jeremy Britton
- Rough River Dam Safety Assurance Project, by Timothy M. O'Leary
- Seepage Collection & Control Systems: The Devil is in the Details , by John W. France
- Dewey Dam Seismic Assessment, by Greg Yankey
- Seismic Stability Evaluation for Ute Dam, New Mexico, by John W. France
- An Overview of Criteria Used by Various Organizations for Assessment and Seismic Remediation of Earth Dams, by Jeffrey S. Dingrando
- A Review of Corps of Engineers Levee Seepage Practices and Proposed Future Changes, by George Sills
- Ground-Penetrating Radar Applications for the Assessment of Pavements, by Lulu Edwards and Don R. Alexander
- Peru Road Upgrade Project, by Michael P. Wielputz
- Slope Stability Evaluation of the Baldhill Dam Right Abutment, by Neil T. Schwanz
- Design and Construction of Anchored Bulkheads with Synthetic Sheet Piles Seabrook, New Hampshire, by Siamac Vaghar and Francis Fung
- Characterization of Soft Claya Case Study at Craney Island, by Aaron L. Zdinak
- Dispersive ClayDispersive Clays – Experience andHistory of the NRCS (Formerly SCS), by Danny McCook
- Post-Tensioning Institute, by Michael McCray
- Demonstration Program Urban Flooding and Channel Restoration in Arid and Semi-Arid Regions (UFDP), by Joan Pope, Jack Davis, Ed Sing, John Warwick, Meg Jonas

Track 6

- State of the Art in Grouting: Dams on Solution Susceptible or Fractured Rock Foundations, by Arthur H. Walz
- Specialty Drilling, Testing, and Grouting Techniques for Remediation of Embankment Dams, by Douglas M. Heenan
- Composite Cut-Offs for Dams, by Dr. Donald A. Bruce and Trent L. Dreese
- State of the Art in Grout Mixes, by James A. Davies
- State of the Art in Computer Monitoring and Analysis of Grouting, by Trent L. Dreese and David B. Wilson
- Quantitatively Engineered Grout Curtains, by David B. Wilson and Trent L. Dreese
- Grout Curtains at Arkabutla Dam: Outlet Monolith Joints and Cracks using Chemical Grout, Arkabutla Lake, MS, by Dale A. Goss
- Chicago Underflow Plan – CUP: McCook Reservoir Test Grout Program, by Joseph A. Kissane
- Clearwater Dam: Sinkhole Repair Foundation Investigation and Grouting Project, by Mark Harris
- Update on the Investigation of the Effects of Boring Sample Size (3" vs 5") on Measured Cohesion in Soft Clays, by Richard Pinner and Chad M. Rachel
- Soil-Bentonite Cutoff Wall Through Free-Product at Indiana Harbor CDF, by Joe Schulenberg and John Breslin
- Soil-Bentonite Cutoff Wall Through Dense Alluvium with Boulders into Bedrock, McCook Reservoir, by William A. Rochford
- Small Project, Big Stability Problem the Block Church Road Experience, by Jonathan E. Kolber
- Determination of Foundation Rock Properties Beneath Folsom Dam, by Michael K. Sharp, José L. Llopis and Enrique E. Matheu
  Waterbury Dam Mitigation, by Bethany Bearmore
- Armor Stone Durability in the Great Lakes Environment, by Joseph A. Kissane
- Mill Creek - An Urban Flood Control Challenge, by Monica B. Greenwell
- Next Stop, The Twilight Zone, by Troy S. O'Neal
- Limitations in the Back Analysis of Shear Strength from Failures, by Rick Deschamps and Greg Yankey
- Reconstruction of Deteriorated Concrete Lock Walls After Blasting and Other Demolition Removal Techniques, by Stephen G. O'Connor

- Flood Fighting Structures Demonstration and Evaluation Program (FFSD), by George Sills
- Innovative Design Concepts Incorporated into a Landfill Closure and Reuse Design Portsmouth Naval Shipyard, Kittery, Maine, by Dave Ray and Kevin Pavlik
- Laboratory Testing of Flood Fighting Structures, by Johannes L. Wibowo, Donald L. Ward and Perry A. Taylor
- Bluff Stabilization Along Lake Michigan, Using Active and Passive Dewatering Techniques, Allegan Co. Michigan, by Rennie Kaunda, Eileen Glynn, Ron Chase, Alan Kehew and Jim Selegean

Track 7

- Case History: Multiple Axial Statnamic Tests on a Drilled Shaft Embedded in Shale, by Paul J. Axtell, J. Erik Loehr, Daniel L. Jones
- The Sliding Failure of Austin Dam Pennsylvania - Revisited, by Brian H. Greene
- M3 –Modeling, Monitoring and Managing: A Comprehensive Approach to Controlling Ground Movements for Protection of Existing Structures and Facilities, by Francis D. Leathers and Michael P. Walker
- Time-Dependent Reliability Modeling for Use in Major Rehabilitation of Embankment Dams and Foundation, by Robert C. Patev
- Lateral Pile Load Test Results Within a Soft Cohesive Foundation, by Richard J. Varuso
- Engineering Geology Challenge Engineering Geology Challenges During Design and Construction of the Marmet Lock Project, by Ron Adams and Mike Nield
- Mill Creek Deep Tunnel Geologic Conditions and Potential Impacts on Design/Construction, by Kenneth E. Henn III
- McAlpine Lock Replacement Instrumentation: Design, Construction, Monitoring, and Interpretation, by Troy S. O'Neal
- Geosynthetics and Construction of the Second Powerhouse Corner Collector Surface Flow Bypass Project, Bonneville Lock and Dam Project, Oregon and Washington, by Art Fong
- McAlpine Lock Replacement Project Foundation Characteristics and Excavation, by Kenneth E. Henn III
- Structural and Geotechnical Issues Impacting The Dalles Spillwall Construction and Bay 1 Erosion Repair, by Jeffrey M. Ament
  Rock Anchor Design and Construction: The Dalles Dam Spillwalls, by Kristie M. Hartfeil
- The Future of the Discrete Element Method in Infrastructure Analysis, by Raju Kala, Johannes L. Wibowo and John F. Peters
- Sensitive Infrastructure Sites - Sonic Drilling Offers Quality Control and Non-Destructive Advantages to Geotechnical Construction Drilling, by John P. Davis

Track 8

- Evaluation of The Use of LithiuEvaluation of The Use of Lithium Compounds in Controlling ASR in Concrete Pavement, by Mike Kelly
- Roller Compacted Concrete for McAlpine Lock Replacement, by David E. Kiefer
- Soil-Cement for Stream Bank Stabilization, by Wayne Adaska
- Using Cement to Reclaim Asphalt Pavements, by David R. Luhr
- Valley Park 100-Yr Flood Protection Project: Use of 'Engineered Fill' in the Item IV-B Levee Core, by Patrick J. Conroy
- Bluestone Dam: AAR –A Case Study, by Greg Yankey
- USDA Forest Service: Unpaved Road Stabilization with Chlorides, by Michael R. Mitchell
- Use of Ultra-Fine Amorphous Colloidal Silica to Produce a High-Density, High-Strength Grout, by Brian H. Green
- Modular Gabion Systems, by George Ragazzo
- Addressing Cold Regions Issues in Pavement Engineering, by Edel R. Cortez and Lynette Barna
- Geology of New York Harbor: Geological and Geophysical Methods of Characterizing the Stratigraphy for Dredging Contracts, by Ben Baker, Kristen Van Horn and Marty Goff
- Rubblization of Airfield Concrete Pavements, by Eileen M. Vélez-Vega
- US Army Airfield Pavement Assessment Program, by Haley Parsons, Lulu Edwards, Eileen Velez-Vega and Chad Gartrell
- Critical State for Probabilistic Analysis of Levee Underseepage, by Douglas Crum,
- Curing Practices for Modern Concrete Production, by Toy Poole
- AAR at Carters Dam: Different Approaches, by James Sanders
- Concrete Damage at Carters Dam, by Toy Poole
  Damaging Interactions Among Concrete Materials, by Toy Poole
- Economic Effects on Construction of Uncertainty in Test Methods, by Toy Poole
- Trends in Concrete Materials Specifications, by Toy Poole
- Spall and Intermediate-Sized Repairs for PCC Pavements, by Reed Freeman and Travis Mann
- Acceptance Criteria Acceptance Criteria for Unbonded Aggregate Road Surfacing Materials, by Reed Freeman, Toy Poole, Joe Tom and Dale Goss
- Effective Partnering to Overcome an Interruption In the Supply of Portland Cement During Construction at Marmet Lock and Dam, by Billy D. Neeley, Toy S. Poole and Anthony A. Bombich

Track 10

- Marmet Lock &Dam: Automated Instrumentation Assessment, Summer/Fall 2004, by Jeff Rakes and Ron Adams
  Success Dam Seismic Remediation

Track 9

- Fern Ridge Dam, Oregon: Seepage and Piping Concerns (Internal Erosion)

Track 11

- Canton Dam Spillway Stability: Is a Test Anchor Program Necessary?, by Randy Mead
- Dynamic Testing and Numerical Correlation Studies for Folsom Dam, by Ziyad Duron, Enrique E. Matheu, Vincent P. Chiarito, Michael K. Sharp and Rick L. Poeppelman

Status of Portfolio Risk Assessment, by Eric Halpin
- Mississinewa Dam Foundation Rehabilitation, by Jeff Schaefer
- Wolf Creek Dam Seepage Major Rehabilitation Evaluation, by Michael F. Zoccola
- Bluestone Dam DSA Anchor Challenges, by Michael McCray
- Clearwater Dam Major Rehab Project, by Bobby Van Cleave
- Design, Construction and Seepage at Prado Dam, by Douglas E. Chitwood
- Seven Oaks Dam: Outlet Tunnel Invert Damage, by Robert Kwan
- An Overview of An Overview of the Dam Safety ProgramManagement Tools (DSPMT), by Tommy Schmidt

Track 12

- Greenup L&D Miter Gate Repair and Instrumentation, by Joseph Padula, Bruce Barker and Doug Kish
- Marmet Locks and Dam Lock Replacement Project, by Jeffrey S. Maynard,
- Status of HSS Inspections in The Portland District, by Travis Adams
- Kansas City District: Perry Lake Project Gate Repair, by Marvin Parks
- Mel Price – Auxiliary Lock Downstream Miter Gate Repair, by Thomas J. Quigley, Brian K. Kleber and Thomas R. Ruf
- J.T. Myers Lock Improvements Project Infrastructure Conference, by David Schaaf and Greg Werncke
- J.T. Myers Dam Major Rehab, by David Schaaf, Greg Werncke and Randy James
- Greenup L&D, by Rodney Cremeans
- McAlpine Lock Replacement Project, by Kathy Feger
- Roller Compacted Concrete Placement at McAlpine Lock, by Larry Dalton
- Kentucky Lock Addition Downstream Middle Wall Monolith Design, by Scott A. Wheeler
- London Locks and Dam Major Rehabilitation Project, by David P. Sullivan
- Replacing Existing Lock 4: Innovative Designs for Charleroi Lock, by Lisa R. Pierce, Dave A. Stensby and Steve R. Stoltz
- Olmsted L&D, Dam In-the-wet Construction, by Byron McClellan, Dale Berner and Kenneth Burg
- Olmsted Floating Approach Walls, by Terry Sullivan
- John Day Navigation Lock Monolith Repair, by Matthew D. Hanson
- Inner Harbor Navigation Canal (IHNC) Lock Replacement, by Mark Gonski
- Comite River Diversion Project, by Christopher Dunn
- Waterline Support Failure: A Case Study, by Angela DeSoto Duncan
- Public Appeal of Major Civil Projects: The Good, the Bad and the Ugly, by Kevin Holden and Kirk Sunderman
- Chickamauga Lock and Dam Lock Addition Cofferdam Height Optimization Study, by Leon A. Schieber
- Des Moines Riverwalk, by Thomas D. Heinold

Track 13

- Folsom Dam Evaluation of Stilling Basin Performance for Uplift Loading for Historic Flows and Modification of Folsom Dam
- Stilling Basin for Hydrodynamic Loading, by Rick L. Poeppelman, Yunjing (Vicky) Zhang, and Peter J. Hradilek
- Seismic Stress Analysis of Folsom Dam, by Enrique E. Matheu
- Barge Impact Analysis for Rigid Lock Walls ETL 1110-2-563, by John D. Clarkson and Robert C. Patev
- Belleville Locks & Dam Barge Accident on 6 Jan 05, by John Clarkson
- Portugues Dam Project Update, by Alberto Gonzalez, Jim Mangold and Dave Dollar
- Portugues Dam: RCC Materials Investigation, by Jim Hinds
- Nonlinear Incremental Thermal Stress Strain Analysis Portugues Dam, by David Dollar, Ahmed Nisar, Paul Jacob and Charles Logie
- Seismic Isolation of Mission-Critical Infrastructure to Resist Earthquake Ground Shaking or Explosion Effects, by Harold O. Sprague, Andrew Whitaker and Michael Constantino
- Obermeyer Gated Spillway S381, by Michael Rannie
- Design of High Pressure Vertical Steel Gates Chicago Land Underflow Plan McCook Reservoir, by Henry W. Stewart, Hassan Tondravi, Lue Tekola,
- Development of Design Criteria for the Rio Puerto Nuevo Contract 2D/2E Channel Walls, by Janna Tanner, David Shiver, and Daniel Russell
- Indianapolis NortIndianapolis North Phase 3A Warfleigh Section
- Design of Concrete Lined Tunnels in Rock CUP McCook Reservoir Distribution Tunnels Contract, by David Force

Track 14

- GSA Progressive Collapse Design Guidelines Applied to Concrete Moment-Resisting Frame Buildings, by David N. Bilow and Mahmoud E. Kamara,
- UFC 4-023-02 Retrofit of Existing Buildings to Resist Explosive Effects, by Jim Caulder
- Summit Bridge Fatigue Study, by Jim Chu
- Quality Assurance for Seismic Resisting Systems, by John Connor
- Seismic Requirements for Arch, Mech, and Elec. Components, by John Connor
- SBEDS - (Single degree of freedom Blast Effects Design Spreadsheets), by Dale Nebuda,
- Design of Buildings to Resist Progressive Collapse UFC 4-023-03, by Bernie Deneke,
- Fatigue and Fracture Assessment, by Jesse Stuart
- Unified Facilities Criteria: Seismic Design for Buildings, by Jack Hayes
- Evaluation and Repair Of Blast Damaged Reinforced Concrete Beams, by MAJ John L. Hudson
- Building an In-house Bridge Inspection Program
- United Facilities CriteriUnited Facilities Criteria Masonry Design for Buildings, by Tom Wright
- USACE Homeland Security Portal, by Michael Pace
- Databse Tools for Civil Works Projects

- Standard Procedure for Fatigue Evaluation of Bridges, by Phil Sauser
- Consolidation of Structural Criteria for Military Construction, by Steven Sweeney
- Cathodic Protectionfor the South Power Plant Reinforcing Steel, Diego Garcia, BIOT, by Thomas Tehada and Miki Funahashi

Track 15

- Engineering Analysis of Airfield Lighting System Lightning Protection, by Dr. Vladimir A. Rakov and Dr. Martin A. Uman
- Dr. Martin A. Uman
- Charleston AFB Airfield Lighting Vault
- UNIFIED FACILITIES CRITERIA (UFC) UFC 3-530-01 Design: Interior, Exterior Lighting and Controls, by Nancy Clanton and Richard Cofer
- Electronic Keycard Access Locks, by Fred A Crum
- Unified Facilities Criteria (UFC) 3-560-02, Electrical Safety, by John Peltz and Eddie Davis
- Electronic Security SystemElectronic Security Systems Process Overview
- Lightning Protection Standards
- Electrical Military Workshop
- Information Technology Systems Criteria, by Fred Skroban and John Peltz
- Electrical Military Workshop
- Electrical Infrastructure in Iraq- Restore Iraqi Electricity, by Joseph Swiniarski

Track 16

- BACnet® Technology Update, by Dave Schwenk
- The Infrastructur Conference 2005, by Steven M. Carter Sr. and Mitch Duke
- Design Consideration for the Prvention of Mold, by K. Quinn Hart
- COMMISSIONING, by Jim Snyder
- New Building Commissioning , by Gary Bauer
- Ventilation and IAQ TheNew ASHRAE Std 62.1, by Davor Novosel
- Basic Design Considerations for Geothermal Heat Pump Systems, by Gary Phetteplace
- Packaged Central Plants
- Effective Use Of Evaporative Cooling For Industrial And Institutional/Office Facilities, by Leon E. Shapiro
- Seismic Protection For Mechanical Equipment
- Non Hazardous Chemical Treatments for Heating and Cooling Systems, by Vincent F. Hock and Susan A. Drozdz
- Trane Government Systems & Services
- LONWORKS Technology Update, by Dave Schwenk
- Implementation of Lon-Based Specifications by Will White and Chris Newman

Track 17

- Utility System Security and Fort Future, by Vicki Van Blaricum, Tom Bozada, Tim Perkins, and Vince Hock
- Festus/Crystal City Levee and Pump Station
- Chicago Underflow Plan McCook Reservoir (CUP) Construction of Distribution Tunnel and Pumps Installation
- Technological Advances in Lock Control Systems, by Andy Schimpf and Mike Maher
- Corps of Engineers in Iraq Rebuilding Electrical Infrastructure, by Hugh Lowe
- Red River of the North at East Grand Forks, MN & Grand Forks, ND: Flood Control Project – Armada of Pump Stations Protect Both Cities, by Timothy Paulus
- Lessons Learned for Axial/Mixed Flow Propeller Pumps, by Mark A. Robertson
- Creek Automated Gate Considerations, by Mark A. Robertson
- HydroAMP: Hydropower Asset Management, by Lori Rux
- Acoustic Leak Detection for Water Distribution Systems, by Sean Morefield, Vincent F. Hock and John Carlyle
- Remote Operation System, Kaskaskia Dam Design, Certification, & Accreditation, by Shane M. Nieukirk
- Lock Gate Replacement System, by Shaun A. Sipe and Will Smith

Track 20

- “Re-Energizing Medical Facility Excellence”, by COL Rick Bond
- Rebuilding and Renovating The Pentagon , by Brian T. Dziekonski,
- Resident Management System
- Design-Build and Army Military Construction, by Mark Grammer
- Defense Acquisition Workforce Improvements Act - Update, by Mark Grammer
- Construction Management @ Risk: Incentive Price Revision – Successive Targets, by Christine Hendzlik
- Construction Reserve Matrix, by Christine Hendzlik
- Award contingent on several factors..., by Christine Hendzlik
- 52.216-17 Incentive Price Revision--Successive Targets (Oct 1997) - Alt I (Apr 1984), by Christine Hendzlik
- Preconstruction Services, by Christine Hendzlik
- Proposal Evaluation Factors, by Christine Hendzlik
- MILCON Transformation in Support of Army Transformation, by Claude Matsui
- Construction Practices in Russia, by Lance T. Lawton

- Partnering as a Best Practice, by Ray Dupont
- USACE Tsunami Reconstruction for USAID, by Andy Constantaras

Track 21

- Dredging Worldwide, by Don Carmen
- SpecsIntact Editor, by Steven Freitas
- SpecsIntact Explorer, by Steven Freitas
- American River Watershed Project, by Steven Freitas
- Unified Facilities Guide Specifications (UFGS) Conversion To MasterFormat 2004, by Carl Kersten
- Unified Facilities Guide Specifications (UFGS) Status and Direction , by Jim Quinn

Workshops

- Design of Buildings to Resist Progressive Collapse UFC 4-023-03, by Bernie Deneke
- Security Engineering and at Unified Facility Criteria (UFC), by Bernie Deneke, Richard Cofer, John Lynch and Rudy Perkey
- Packaged Central Plants, by Trey Austin

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

NDIA

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

2005 Tri-Service Infrastructure Systems Conference & Exhibition

"Re-Energizing Engineering Excellence"

ON-SITE AGENDA

The America's Center
St. Louis Convention Center
St. Louis, MO
August 2-4, 2005
Event # 5150

ISC
Tri-Service Infrastructure Systems Conference & Exposition 2005

2005 Tri-Service Infrastructure Systems Conference & Exhibition

AGENDA

Monday, August 1, 2005

8:00 AM-9:00 PM	Exhibit Move-In
12 Noon-5:00 PM	Registration

Tuesday, August 2, 2005

7:00 AM-8:00 AM	Registration and Continental Breakfast
8:00 AM-8:15 AM Ferrara Theatre	Welcome and Introduction
8:15 AM-9:00 AM Ferrara Theatre	The Future of Engineering and Construction Panel Moderator: *Mr. Don Basham, Chief, Engineering & Construction, USACE* Panelists: *LTG Carl A. Strock, Commander, USACE* *Dr. James Wright, Chief Engineer NAVFAC*
9:00 AM-9:45 AM Ferrara Theater	Keynote Address The Lord of the Things: The Future of Infrastructure Technologies *Mr. Paul Doherty, AIA, Managing Director,* *General Land Corporation*
9:45 AM-10:15 AM	Break
10:15 AM-11:15 AM Ferrara Theatre	USACE Engineering and Construction Panel Moderator: *Mr. Don Basham, Chief, Engineering & Construction, USACE* Panelists: *MG Donald T. Riley, Director, Civil Works, USACE* *BG Bo M. Temple, Director, Military Programs, USACE* *Dr. Michael J. O'Connor, Director, R&D*
10:15 AM-11:15 AM Room 225	Navy General Session
11:00 AM - 7:00 PM	Exhibits Open
11:15 AM-1:00 PM	Lunch in Exhibit Hall (on your own)
11:15 AM-1:00 PM Washington G	Women's Career Lunch Session (Bring your lunch from Exhibit Hall) Moderator: *Ms. Demi Syriopoulou, HQ USACE* Opening Remarks: *LTG Carl A. Strock, Commander, USACE* Presentations & Discussion: *Dwight Beranek, Kristine Allaman, Donald Basham, HQ USACE*
1:00 PM-1:55 PM Ferrara Theatre	Introduction to Multi-Disciplinary Tracks

Tuesday, August 2, 2005

2:00 PM-2:50 PM — 1st Round of Multi-Disciplinary Concurrent Sessions (Continued)

Track 1: Acquisition Strategies for Civil Works
Room 230
Walt Norko

Track 2: Risk and Reliability Engineering
Room 231
Anjana Chudgar
David Schaaf

Track 3: Portfolio Risk Assessment
Room 232
Eric Halpin

Track 4: Hydrology, Hydraulics and Coastal Engineering
Room 240 Support for USACE
Jerry Webb
Darryl Davis

Track 5: Civil Works R&D Forum
Room 241
Joan Pope

Track 6: Civil Works Security Engineering
Room 242
Joe Hartman
Bryan Cisar

Track 7: Building Information Model Applications
Room 226
Brian Huston
Daniel Hawk

Track 8: Design Build for Military Projects
Room 220
Mark Grammer

Track 9: Army Transformation/Global Posture Initiative/
Room 221 Force Modernization
Al Young
Claude Matsui

Track 10: Force Protection - Army Access Control Points
Room 222
John Trout

Track 11: Cost Engineering Forum on Government Estimates
Room 227 vs. Actual Costs
Ray Lynn *Jack Shelton* *Kim Callan*
Miguel Jumilla *Ami Ghosh* *Joe Bonaparte*

Track 12: Engineering & Construction Information Technology
Room 228
MK Miles

Track 13: Sustainable Design
Room 223
Harry Goradia

Track 14: ACASS/CCASS/CPARS
Room 224
Ed Marceau
Marilyn Nedell

Track 15: Whole Building Design Guide
Room 229
Earle Kennett

Tuesday, August 2, 2005

2:50 PM-3:30 PM	Break in Exhibit Hall
3:30 PM-4:20 PM	2nd Round of Multi-Disciplinary Sessions
4:30 PM-5:20 PM	3rd Round of Multi-Disciplinary Sessions
5:30 PM-7:00 PM	Ice Breaker Reception in Exhibit Hall

Wednesday, August 3, 2005

7:00 AM-8:00 AM	Registration and Continental Breakfast
8:00 AM-9:30 AM	Concurrent Sessions (Please Refer to Concurrent Session Schedule on the Following Pages)
9:00 AM	Exhibit Hall Opens
9:30 AM-10:30 AM	Break in Exhibit Hall
10:30 AM-12:00 Noon	Concurrent Sessions (Please Refer to Concurrent Session Schedule on the Following Pages)
12:00 Noon-1:30 PM	Lunch in Exhibit Hall
1:30 PM-3:00 PM	Concurrent Sessions (Please Refer to Concurrent Session Schedule on the Following Pages)
3:00 PM-4:00 PM	Break in Exhibit Hall
4:00 PM-5:30 PM	Concurrent Sessions
5:00 PM	Exhibit Hall Closes

Thursday, August 4, 2005

7:00 AM-8:00 AM	Registration and Continental Breakfast
8:00 AM-9:30 AM	Concurrent Sessions (Please Refer to Concurrent Session Schedule on Following Pages)
9:30 AM-10:30 AM	Break in Exhibit Hall (Last Chance to view Exhibits)
10:30 AM-12:00 Noon	Concurrent Sessions (Please Refer to Concurrent Session Schedule on Following Pages)
12:00 Noon-1:30 PM	Lunch (On your own)
12:00 Noon-6:00 PM	Exhibits Move-Out
1:30 PM-3:00 PM	Concurrent Sessions (Please Refer to Concurrent Session Schedule on Following Pages)
3:00 PM-3:30 PM	Break
3:30 PM-5:00 PM	Concurrent Sessions (Please Refer to Concurrent Session Schedule on following pages)

Wednesday, August 3, 2005 Concurrent Sessions

HH&C Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 220	**TRACK 1 Coastal Structures** Session 1A	Protecting the NJ Coast using large stone seawalls — *Cameron Chasten*	Chicago shoreline storm damage reduction project — *Andrew Bezinger*	Risk and reliability in coastal structure design — *Jeffrey Melby*	**TRACK 1 Coastal Regional Manangement** Session 1B	Cascade: An integrated regional model for decision support — *Nicholas Kraus*	Upper Texas coast sediment transport modeling & sediment budgets — *David King*	Sediment compatibility for beach nourishment in North Carolina — *Gregory Williams*
Room 221	**TRACK 2 Ecological Engineering & Design** Session 2A	Ecological and engineering considerations for dam decommissioning, retrofits and operations — *Jock Conyngham*	Hydraulic design of tidegates and other water control structures for ecosystem restoration on the Columbia Estuary — *Patrick O'Brien*	Innovative Integration of engineering and biological tools aids hydraulic structure design for restoring T&E fish — *Andrew Goodwin*	**TRACK 2 Ecological Engineering & Design** Session 2B	Innovative hydraulic structure design at Lower Granite Dam: design that saves water and salmon — *Lynn Reese*	Impacts of using a spillway for juvenile fish passage on typical design criteria — *Robert Buchholz*	Hydraulic design of juvenile fish passage facility for reservoir with wide range of pool elevation - Hanson Dam — *Dennis Mekkers*
Room 222	**TRACK 3 Modeling** Session 3A	Corps involvement in the FEMA map modernization program — *Kete White*	Innovative approximate study method for FEMA map modernization program — *John Hunter*	Flood fight structures demonstration evaluation program — *Fred Pinkard*	**TRACK 3 Modeling** Session 3B	Integrating climate dynamics into water resources planning and management — *Kate White*	Risk and uncertainty in flood damage reduction studies — *Rob Moyer*	Uncertainty analysis and stochastic simulation — *Jacke Hallberg*
Room 223	**TRACK 4 H&H Aspects of Dam Safety** Session4A	Hydrologic aspects of operating in failure mode: Fern Lake — *Bruce Duffe*	Dam safety study with cascading failures — *Gordon Lance*	Rough river spillway capacity — *Richard Pruitt*	**TRACK 4 International/ Military H&H** Session 4B	Capability restoration and historic marsh restoration — *Fauwaz Hanbali*	USACE capacity building effort for Iraq MoWR — *Steven Wilhelms*	USACE support of CMEP in 2004 — *Mark Jensen*

Break in Exhibit Hall

12 Noon — **Lunch in Exhibit Hall**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	4:00 PM	4:30 PM	5:00 PM
Room 220	**TRACK 1 Coastal Sediments** Session 1C	Evaluating beachfill project performance in the NAP — *Monica Chasten*	USACE's regional coastal mapping program — *Jennifer Wozencraft*	US Naval Academy flood damage reduction project using structural and non-structural measures — *Stacey Underwood*	**TRACK 1 Shore Protection Projects** Session 1D	Hurricane Isabel effects on communities — *Jane Jablonski*	Repair of the shore protection projects adversly affected by the hurricanes of 2004 — *Rick McMillen*	Shore protection project performance assessmet — *Sharon Haggett*
Room 221	**TRACK 2 Modeling Ecological Restoration/Systems Assessment** Session 2C	Regional modeling requirements for ecosystem restoration — *Maged Hussein*	Tools for wetlands permit evaluation: Modeling groundwater and surface water distribution systems — *Cary Talbot*	Current research in fate and transport of chemical and biological contaminants in water distribution systems — *Mark Ginsberg*	**TRACK 2 Ecosystem Habitat Restoration** Session 2D	Aquatic habitat restoration in the lower Missouri River — *Chance Bittner*	Missouri River restoration: shallow water habitat creation — *Daniel Pridal*	Ecosystem restoration for fish and wildlife habitat on the upper Mississippi River — *Jon Hendrickson*
Room 222	**TRACK 3 River Morphology** Session 3C	Geomorphology study of the Mississippi river — *Edward Braurer*	Bank erosion and morphology of the Kaskaskia river — *Michael Rodgers*	Sediment movement at Kansas City from water years 1920 to 2004 — *Alan Tool*	**TRACK 3 Modeling River Sedimentation** Session 3D	Sediment impact assessment model (SIAM) — *David Biedenharn*	Sediment modeling of MS River, Cairo to Gulf — *Basil Arthur*	Sediment modeling of rivers — *Charlie Berger*
Room 223	**TRACK 4 GIS and Surveying** Session 4C	GIS tools available now to support HHC — *Timothy Pangburn*	High resolution bathymetry and fly-through visualization — *Paul Clouse*	GIS & surverying to support national FEMA — *Mark Flick*	**TRACK 4 GIS and Surveying** Session 4D	Update flood emergency plans with GIS and HEC-RAS — *Stephen Stello*	High resolution visualizations of multibeam data: lower Mississippi River — *Thomas Tobin*	GIS in SWWRP — *Andrew Bruzewicz*

Break in Exhibit Hall

Wednesday, August 3, 2005 Concurrent Sessions

Geotechnical Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 226	**TRACK 5**	Levee lowering for the Lewis & Clark bi-centennial celebration	Conduits through embankment dams - best practices for design, construction, problem id and evaluation, inspection, maintenance, renovation & repair		2-D liquefaction evaluation with q4MESH	Unlined spillway erosion risk assessment	Seismic remediation of the Clemson upper and lower diversion dams: evaluation, conceptal design and design (P1)
	Session 5A	***Robert Berger***	***Dave Pezza***	***Douglas Chitwood***	**Session 5B** ***David Serafini***	***Johannes Wibowo***	***Ben Foreman***
Room 227	**TRACK 6**	USACE dams on solution susceptible or highly fractured rock foundations	Special drilling and grouting techniques for remedial work in embankment dams	Composite grouting & cutoff wall solutions	State of the art in grout mixes	State of the art in computer monitoring, control, and analysis of grouting	Quantitatively engineered grout courtains
	Session 6A	***Art Walz***	***Doug Heenan***	***Donald Bruce***	**Session 6B** ***James Davies***	***Trent Dreese***	***David Wilson***
Room 228	**TRACK 7**	Case history: multiple axial statnamic test on a drilled shaft embedded in shale	Austin Dam, Pennsylvania: the sliding failure of a concrete gravity dam revisited	M^3 (Modeling, Monitoring and Manufacturing) - a comprehensive approach to controlling ground movements for protecting existing structures and facilities	Controlled modulus columns: A ground improvement technique	Time-dependent reliability models for use in major rehabilitation of embankment dams and foundations	Engineering geology design challenges at the Soo Lock replacement project
	Session 7A	***Paul Axtell***	***Brian Greene***	***Michael Walker***	**Session 7B** ***Martin Taube***	***Robert Patev***	***Mike Nield***
Room 229	**TRACK 8**	Evaluation of the use of lithium nitrate in controlling alkali-silica reactivity in an existing concrete pavement	Use of self-consolidating concrete in the installation of bulhead slots - Lessons learned in the use of this innovative concrete material	Roller compacted concrete for McAlpine lock walls	Soil-cement for stream bank stabilization	Using cement to reclaim asphalt pavements	Valley park 100-year flood protection project: use of "engineered fill" in item 4b levee core
	Session 8A	***Mike Kelly***	***Darrell Morey***	***David Kiefer***	**Session 8B** ***Wayne Adaska***	***David Luhr***	***Patrick Conroy***

Break in Exhibit Hall

12 Noon — **Lunch in Exhibit Hall**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	4:00 PM	4:30 PM	5:00 PM
Room 226	**TRACK 5**	Seismic remediation of the Clemson upper and lower diversion dams: deep soil mix construction	Historical changes in the state-of-the-art of seismic engineering & effects of those changes on the seismic response studies of large embankement dams	New Iwakuni runway	Internal erosion and piping at Fern Ridge dam: Problems and solutions	Rough river dam safety assurance project	Seepage collection and control systems: The devil is in the details
	Session 5C	***Ben Foreman***	***Samuel Stacy***	***Vincent Donnally***	**Session 5D** ***Jeremy Britton, Ph.D.***	***Timothy O'Leary***	***John France***
Room 227	**TRACK 6**	Grout courtains at Arkabutla Dam outlet monolith joints using chemical grout to seal joints, Arkabutla, MS	Results from a large-scale grout test program, Chicago underflow plan (CUP) McCook Reservoir	Clearwater Dam - foundation drilling and grouting for repair of sinkholes	Update on the investigation of the effects of boring sample size (3' vs 5") on measured cohesion in soft clays	Soil-bentonite cutoff wall through free-product at Indiana Harbor CDF	Soil-bentonite cutoff wall through dense alluvium with boulders into bedrock, McCook Reservoir
	Session 6C	***Dale Goss***	***Joseph Kissane***	***Mark Harris***	**Session 6D** ***Richard Pinner***	***Joseph Schulenberg***	***William Rochford***
Room 228	**TRACK 7**	Engineering geology during design and construction of the Marmet lock project	Mill Creek deep tunnel - Geological affects on proposed structures and construction techniques	Earth pressure loads behind the new McAlpine Lock replacement project	Geosynthetics and construction of the Bonneville lock and dam second powerhouse corner collector surface flow bypass project	McAlpine lock replacement - foundation characteristics and excavation	
	Session 7C	***Michael Nield***	***Tres Henn***	***Troy O'Neal***	**Session 7D** ***Art Fong***	***Kenneth Henn***	
Room 229	**TRACK 8**	What to do if your dam is expanding: a case study	Unpaved road stabilization with chlorides	Use of ultra-fine amorphous colloidal silica to produce a high-density, high-strength rock-matching grout for instrumentation grouting	Innovative techniques in the Gabion system	Addressing cold regions issues in pavement engineering	Geology of New York Harbor - geological and geophysical methods of characterizing the stratigraphy for dredging contracts
	Session 8C	***Greg Yankey***	***Michael Mitchell***	***Brian Green***	**Session 8D** ***George Ragazzo***	***Lynette Barna***	***Ben Baker***

Break in Exhibit Hall

Wednesday, August 3, 2005 Concurrent Sessions

Structural Engineering Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 240	**TRACK 12 Civil Works Structural**	Recent changes to Corps guidance on steel hydraulic structures	Crack repairs and instrumentation of Greenup L&D miter gate	Recent hydraulic steel structures findings in the Portland district	**TRACK 12 Civil Works Structural**	Perry Lake gate repair	Mel Price auxiliary lock gate repair	Mel Price auxiliary lock gate repair (Continued)
	Session 12A	*Joe Padula*	*Doug Kish*	*Travis Adams*	**Session 12B**	*Marvin Parks*	*Andrew Schimpf*	*Andrew Schimpf*
Room 241	**TRACK 13 Civil Works Structural**	Folsom Dam evaluation of stilling basin performance for uplift loading for historic flows	Rehabilitation of Folsom Dam stilling basin	Seismic stability evaluation of Folson Dam	**TRACK 13 Civil Works Structural**	Seismic stress analysis of Folsom Dam	Barge impact guidance for rigid lock walls, ETL 110-2-563 and probalistic barge impact analysis	Belleville barge accident
	Session 13A	*Rick Poeppelman*	*Rick Poeppelman*	*Enrique Matheu*	**Session 13B**	*Enrique Matheu*	*John Clarkson*	*John Clarkson*
Room 242	**TRACK 14 Bridges/ Buildings**	The USACE bridge management system	Standard procedures for fatigue evaluation of bridges	Fatigue and fracture assessment of Jesse Stuart Highway Bridge	**TRACK 14 Bridges/ Buildings**	Building an in-house bridge inspection program	Fatigue analysis of Summit bridge	Consolidation of Structural criteria for military construction
	Session 14A	*Phil Sauser*	*Phil Sauser*	*John Jaeger*	**Session 14B**	*Jennifer Laning*	*Jim Chu*	*Steve Sweeney*

Break in Exhibit Hall

12 Noon — **Lunch in Exhibit Hall**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	4:00 PM	4:30 PM	5:00 PM
Room 240	**TRACK 12 Civil Works Structural**	Overview of John T. Myers locks improvements project	John T. Myers rehabilitation study	Ohio River Greenup Lock extension	**TRACK 12 Civil Works Structural**	McAlpine lock replacement project, project summary and status of construction	Results of Roller Compacted concrete placement at the McAlpine lock replacement project	Tennessee Valley authority Kentucky lock addition downstream middle wall monoliths
	Session 12C	*Greg Werncke*	*Greg Werncke*	*Rodney Cremeans*	**Session 12D**	*Kathleen Feger*	*Larry Dalton*	*Scott Wheeler*
Room 241	**TRACK 13 Civil Works Structural**	Portugues Dam, Ponce, Puerto Rico project update	Portugues Dam, Ponce, Puerto Rico, RCC design and testing program	Portugues Dam, Ponce, Puerto Rico, Thermal analysis of hydration and subsequent cooling of RCC	**TRACK 13 Civil Works Structural**	Miter gate anchorage design	Obermeyer gated spillway project - S381	McCook Reservoir design of high pressure steel gates
	Session 13C	*Jim Mangold*	*Jim Hinds*	*Ahmed Nisar*	**Session 13D**	*Andy Harkness*	*Michael Rannie*	*Luelseged Tekola*
Room 242	**TRACK 14 Brigdes/ Buildings**	Unified facilities criteria seismic design for buildings	Seismic requirements for architectural, mechanical and electrical components	Quality assurance for seismic resisting systems	**TRACK 14 Bridges/ Buildings**	Unified facilities criteria masonry structural design for buildings	Cathodic protection of building reinforcing steel (in Diego Garcia)	USACE Homeland security web portal
	Session 14C	*Jack Hayes*	*John Connor*	*John Connor*	**Session 14D**	*Tom Wright*	*Thomas Tehada*	*Mike Pace*

Break in Exhibit Hall

Wednesday, August 3, 2005 Concurrent Sessions

Dam Safety Track & Construction Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 224	**TRACK 10 Dam Safety**	Tuttle Creek warning and alert systems	Lessons from the dam failure warning system exercise - Tuttle Creek	Tuttle Creek ground modification treatability program	**TRACK 10 Dam Safety**	Dam safety analysis of Cannelton Dam	John Martin Dam, CO - Dam safety structural upgrades	Vesuvius Lake Dam rehabilitation
	Session 10A	***Bill Empson***	***Bill Empson***	***Bill Empson***	**Session 10B**	***Terry Sullivan***	***George Diewald***	***Susan Peterson***
Room 225	**TRACK 11 Dam Safety**	Canton lake spillway stabilization project: IS a test anchor program NECESSARY?	Dynamic testing and numerical correlation studies for Folsom dam	Status of portfolio risk assessment	**TRACK 11 Dam Safety**	Mississinewa Dam remediation	Wolf creek seepage history	Blue dam major rehabilitation
	Session 11A	***Randy Mead***	***Ziyad Duron***	***Eric Halpin***	**Session 11B**	***Jeff Schaefer***	***Michael Zoccola***	***Michael McCray***
Room 230	**TRACK 19 Construction**	RMS Update	RMS Update (Continued)	Updated CQM for Contractors Course	**TRACK 19 Construction**	Lessons learned on major construction projects	Update on safety issues - Safety manual 385-1-1	Update on safety issues - safety manual 385-1-1 (continued)
	Session 19A	***Haskell Barker***	***Haskell Barker***	***Walt Norko***	**Session 19B**	***Jim Cox***	***Charles Ray Waits***	***Charles Ray Waits***
Room 231	**TRACK 20 Construction**	Construction methods in Russia	Construction methods in Russia (Continued)	Renovating the Pentagon using Design/Build delivery	**TRACK 20 Construction**	Completion of the Olmsted approach walls	Completion of the Olmsted approach walls (Continued)	Construction management at risk
	Session 20A	***Lance Lawton***	***Lance Lawton***	***Brian Dziekonski***	**Session 20B**	***Dale Miller***	***Dale Miller***	***Christopher Prinslow***

Break in Exhibit Hall

12 Noon **Lunch in Exhibit Hall**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	4:00 PM	4:30 PM	5:00 PM
Room 224	**TRACK 10 Dam Safety**	Project specific risk analysis - Success Dam	Dam safety lessons learned, Winter storm 2005, Muskingum & Scioto Basins	Dam security and Dams Government Coordinating Council	**TRACK 10 Dam Safety**	Prompton Dam hydrologic deficiency and spillway modification	"Well, that's water over the dam" - Rough River spillway adequacy design	Roller-compacted concrete for dam spillways and overtopping protection
	Session 10C	***Ronn Ross***	***Charles Barry***	***Roy Braden***	**Session 10D**	***Troy Cosgrove***	***Richard Pruitt***	***Fares Abdo***
Room 225	**TRACK 11 Dam Safety**	Clearwater Dam major rehabilitation	Success dam seismic dam safety modification	Problems on the Santa Ana River - Prado Dam	**TRACK 11 Dam Safety**	Problems on the Santa Ana River - Seven Oaks Dam	Dam safety program management tools	
	Session 11C	***Bobby Van Cleave***	***Norbert Suter***	***Douglas Chitwood***	**Session 11D**	***Robert Kwan***	***Tommy Schmidt***	
Room 230	**TRACK 19 Construction**	3D Modeling and impact on constructability	3D Modeling and impact on constructability (Continued)	Construction in Iraq & Afganistan	**TRACK 19 Construction**	Air Force streamlining Design/Build	Air Force streamlining Design/Build (Continued)	Sustainable design requirements & construction implementation
	Session 19C	***Gary Cough***	***Gary Cough***	***Walt Norko***	**Session 19D**	***Joel Hoffman***	***Joel Hoffman***	***Harry Goradia***
Room 231	**TRACK 20 Construction**	Tsunami reconstruction	Tsunami reconstruction (Continued)	Military construction transformation in support of Army transformation	**TRACK 20 Construction**	MEDCOM Construction Issues	MEDCOM Construction Issues (Continued)	*TBA*
	Session 20C	***Andy Constantaras***	***Andy Constantaras***	***Sally Parsons***	**Session 20D**	***Rick Bond***	***Rick Bond***	

Break in Exhibit Hall

Wednesday, August 3, 2005 Concurrent Sessions

Electrical & Mechanical Engineering Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room A	**TRACK 15 Military Electrical**	Tri-Service Electrical Criteria Overview -	Tri-Service Electrical Criteria Overview - (Continued)	Tri-Service Electrical Criteria Overview -(Continued)	**TRACK 15 Military Electrical**	Interior/Exterior and security lighting criteria	Information technology systems criteria	Information technology systems criteria (Continued)
	Session 15A	***Tri-Service Panel***	***Tri-Service Panel***	***Tri-Service Panel***	**Session 15B**	***Tri-Service Panel***	***Tri-Service Panel***	***Tri-Service Panel***
Room B	**TRACK 16 Military Mechanical**	Building Commissioning	HVAC Commissioning	Ventilation and indoor air quality	**TRACK 16 Military Mechanical**	Ventilation and indoor air quality (Continued)	Refrigerant implications for HVAC specifications, selection, and o&m - now and future	Refrigerant implications for HVAC specifications, selection, and o&m - now and future (Continued)
	Session 16A	***Dale Herron***	***Dale Herron***	***Davor Novosel***	**Session 16B**	***Davor Novosel***	***Mike Thompson***	***Mike Thompson***
Room D	**TRACK 17 Military Mechanical / Electrical**	Sustainable design update			**TRACK 17 Military Mechanical / Electrical**	Utility systems security and fort future	Acoustic leak detection for utilities distribution systems	Acoustic leak detection for utilities distribution systems (Continued)
	Session 17A	***Harry Goradia***			**Session 17B**	***Vicki L. Van Blaricum***	***Sean Morefield***	***Sean Morefield***
Room E	**TRACK 18 Civil Mechanical**	Emsworth Dam vertical lift gate hoist replacement	Hydraulic drive for Braddock Dam	John Day navigation lock upstream lift gate wire rope failure	**TRACK 18 Civil Mechanical**	Overhead bulkhead at Olmstead Lock	Replacement of gate # 5 intermediate gear and pinion at RC Byrd Lock and Dam	Mechanical design issues during construction of McAlpine Lock
	Session 18A	***John Nites***	***Janine Krempa***	***Ronald Wridge***	**Session 18B**	***Rick Schultz***	***Brenden McKinley***	***Richard Nichols***

Break in Exhibit Hall

12 Noon — **Lunch in Exhibit Hall**

	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM
Room A	**TRACK 15 Military Electrical**	Mass notification system	Mass notification system (Continued)	Electronic card access locks	**TRACK 15 Military Electrical**	Lightning protection standards	Lightning and surge protection	Lightning and surge protection (Continued)
	Session 15C	***Tri-Service Panel***	***Tri-Service Panel***	***Fred Crum***	**Session 15D**	***Richard Bouchard***	***Tri-Service Panel***	***Tri-Service Panel***
Room B	**TRACK 16 Military Mechanical**	Basic design considerations for geothermal heat pump systems	Basic design considerations for geothermal heat pump systems (Continued)	Pentagon renovation	**TRACK 16 Military Electrical**	Effective use of evaporative cooling for industrial and institutional/office facilities	Efective use of evaporative cooling for industrial and institutional/office facilities (Continued)	Non-hazardous chemical treatments for heating and cooling systems
	Session 16C	***Gary Phetteplace***	***Gary Phetteplace***	***Mitch Duke***	**Session 16D**	***Leon Shapiro***	***Leon Shapiro***	***Vincent Hock***
Room D	**TRACK 17 Civil Mechanical / Electrical**	Hydropower asset management partnership (hydroAMP)	New gas fueled/diesel fueled turbine powered electrical generating station in Iraq	The construction of distribution tunnels and pump installation for the metropolitan Chicago sewer systems	**TRACK 17 Civil Mechanical / Electrical**	The Festus/Crystal City levee and pump station project	Remote operations for Kaskaskia Dam	Technological advances in lock control systems
	Session 17C	***Lori Rux***	***Lester Lowe***	***Ernesto Go***	**Session 17D**	***Stephen Farkas***	***Shane Nieukirk***	***Andy Schimpf***
Room E	**TRACK 18 Civil Mechanical**	New coating products for civil works structures	New guide specification for procurement of turbine oils	Synchronous condensing with large Kaplan turbine - A case study	**TRACK 18 Civil Mechanical**	Acquifer storage and recovery (ASR) system	Wastewater infrastructure improvements in Appalachia	Storm water pumps
	Session 18C	***Al Beitelman***	***John Micetic***	***Brian Moentenich***	**Session 18D**	***Gerald Deloach***	***James Sadler***	***Thomas Jamieson***

Break in Exhibit Hall

Thursday, August 4, 2005 Concurrent Sessions

HH&C Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 220	**TRACK 1 Sedimentation & New Concepts** Session 1E	Ice jams, contaminated sediment and structures Clark Fork River, MT — *Andrew Tuthill*	Increased bed erosion due to ice — *John Hains*	Monitoring the Mississippi River using GPS coordinated video — *James Gutshall*	**TRACK 1 Sedimentation, Case Examples** Session 1F	Watershed approach to stream stability the reduction of nutrients — *John B. Smith*	Monitoring the effects of sedimentation from Mount St. Helen — *Alan Donner*	Navigation and environmental interests in alleviating repetitive dredging — *Jason Brown*
Room 221	**TRACK 2 Water Management** Session 2E	Enhancements and new capabilities of HEC-ResSim 3.0 — *Fauwaz Hanbali*	Transition to Oracle based data system — *Joel Asunskis*	Accessing real time Mississippi Valley water level data — *Rich Engstrom*	**TRACK 2 Water Management** Session 2F	Hurricane Season 2004 — *Susan Sylvester*	Reevaluation of a project's flood control benefits — *Ferris Chamberlin*	Helmand Valley water management plan — *Jason Needham*
Room 222	**TRACK 3 Case Studies** Session 2E	Red River of the north flood protection project — *Michael Lesher*	Southeast Arkansas flood control & water supply feasibility study — *Thomas Brown*	McCook and Thorton tunnel and reservoir modeling — *David Kiel*	**TRACK 3 Case Studies** Session 3F	Ala Wai Canal Project, Honolulu, Oahu, Hawaii — *Lynnette Schapers*	Missouri River geospatial decision support framework — *Brian Baker*	Systemic analysis of the Mississippi & Illinois Rivers — *Dennis Stephens*
Room 223	**TRACK 4 Modeling** Session 4E	Hydrologic models supported by ERDC — *Robert Wallace*	HEC-HMS Version 3.0 new features — *Jeff Harris*	SEEP2D & GMS: Simple tools for solving a variety of seepage problems — *Clarissa Hansen*	**TRACK 4 Modeling** Session 4F	Water quality and sediment transport in HEC-RAS — *Mark Jensen*	Advances to the GSSHA program — *Aaron Byrd*	Software integration for watershed studies HEC-WAT — *Chris Dunn*

Break in Exhibit Hall

12 Noon — **Lunch**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM
Room 220	**TRACK 1 Water Quality Management** Session 1G	San Francisco Bay Mercury TMDL-Implications for constructed wetlands — *Herb Fredrickson*	Abandoned mine land: Eastern and Western perspectives — *Kate White*	A lake tap for temperature control tower construction at Cougar Dam — *Steve Schlenker*	**TRACK 1 Watershed Management** Session 1H	Demonstrating innovative river restoration technologies: Truckee River, NV — *Chris Dunn*	Comprehensive watershed restoration in the Buffalo district — *Anthony Friona*	Translating the hydrologic tower of Babel — *Dan Crawford*
Room 221	**TRACK 2 Water Management** Session 2G	Developing reservoir operation plans to manage erosion — *Patrick O'Brien*	New approaches to water management decision making — *James Barton*	Improved water supply forecasts for Kooteny basin using principal components regression — *Randal Wortman*	**TRACK 2 Water Management** Session 2H	Prescriptive reservoir modeling and ROPE study — *Jason Needham*	Missouri River mainstem operations — *Larry Murphy*	Res-Sim model for the Columbia River — *Arun Mylvahanan*
Room 222	**TRACK 3 Section 227** Session 3G	Section 227 Workshop/ Program Review — *William Curtis*	Section 227 Workshop/ Program Review (Continued) — *William Curtis*	Section 227 Workshop/ Program Review (Continued) — *William Curtis*	**TRACK 3 Section 227** Session 3H	Section 227 Workshop/ Program Review — *William Curtis*	Section 227 Workshop/ Program Review (Continued) — *William Curtis*	Section 227 Workshop/ Program Review (Continued) — *William Curtis*
Room 223	**TRACK 4 Modeling** Session 4G	Little Calumet River unsteady flow model conversion — *Rick Ackerson*	Kansas City River basin model — *Edward Parker*	Design guidance for breakup ice control — *Andrew Tuthill*	**TRACK 4 Modeling** Session 4H	Forebay flow simulations using Navier-Stokes code — *Charlie Berger*	Use of regularizatino as a method for watershed model calibration — *Brian Skahill*	Demonstration program in the arid southwest — *Margaret Jonas*

Break

Thursday, August 4, 2005 Concurrent Sessions

Geotechnical Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 226	**TRACK 5**	Dynamic deformation analyses Dewey Dam Huntintong District Corps of Engineers	Seismic stability evaluation for Ute Dam, NM	An overview of criteria used by various organizations for assessments and seismic remediation of earth dams	**TRACK 5**	USACE seepage berm design criteria and district practices	Ground penetrating radar applications for the assessment of airfield pavements	Challenges of the Fernando Belaunde Terry road upgrade Campanillia to Pizana - Peru road project
	Session 5E	***Greg Yankey***	***John France***	***Sean Carter***	**Session 5F**	***George Sills***	***Lulu Edwards***	***Michael Wielputz***
Room 227	**TRACK 6**	Small geotechnical project, big stability problem - The Block Church Road experience	Geophysical investigation of foundation conditions beneath Folsom Dam	Bioengineering slope stabilization techniques coupled with traditional engineering applications - The result a stable slope	**TRACK 6**	Shoreline armor stone quality issues	Mill Creek - An urban flood control challenge	Next stop, The Twilight Zone
	Session 6E	***Jonathan Kolber***	***Jose Llopis***	***Bethany Bearmore***	**Session 6F**	***Joseph Kissane***	***Monica Greenwell***	***Troy O'Neal***
Room 228	**TRACK 7**	The geotechnical and structural issues impacting the Dalles spillway construction	The Dalles spillway engineering and design	The future of the discrete element method in infrastructure analysis	**TRACK 7**	Evaluating the portable falling weight deflectometer as a low-cost technique for posting seasonal load restrictions on low volume payments	Soil structure interaction effects in the seismic evaluation of success dam control tower	Olmsted locks and Dam project geotechnical/construction issues
	Session 7E	***Kristie Hartfeil***	***Kristie Hartfeil***	***Raju Kala***	**Session 7F**	***Maureen Kestler***	***Michael Sharp***	***Jeff Schaefer***
Room 229	**TRACK 8**	Rubblization of airfield concrete pavement	US Army airfield pavement assessment program	Critical state for probabilistic analysis of levee underseepage	**TRACK 8**	Curing practices for modern concrete construction	AAR at Carters Dam, a different approach	Concrete damage at Carters Dam, GA
	Session 8E	***Eileen Velez-Vega***	***Haley Parsons***	***Douglas Crum***	**Session 8F**	***Toy Poole***	***James Sanders***	***Toy Poole***

Break in Exhibit Hall

12 Noon — **Lunch**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM
Room 226	**TRACK 5**	Slope stability evaluation of the Baldhill Dam right abutment	Lateral pile load test results within a soft cohesive foundation	Design and construction of anchored bulheads for river diversion, Seabrook, NH	**TRACK 5**	Characterization of soft marine clays - A case study at Craney Island	50 years of NRSC experience with engineering problems caused by dispersive clays	Changes in the post-tensioning institutes new (4th Ed. 2004) "Recommendations for prestressed rock and soil anchors"
	Session 5G	***Neil Schwanz***	***Richard Varuso***	***Siamac Vaghar***	**Session 5H**	***Aaron Zdinak***	***Danny McCook***	***Michael McCray***
Room 227	**TRACK 6**	Perils in back analysis failures	Reconstruction of deteriorated lock walls concrete after blasting and other demolition removal techniques	Flood fighting structures demonstrations and evaluation program	**TRACK 6**	Innovative design concepts incorporated into a landfill closure and reuse design	Laboratory testing of flood fighting structures	Bluff stabilization along Lake Michigan using active and passive dewatering techniques
	Session 6G	***Greg Yankey***	***Steve O'Connor***	***George Sills***	**Session 6H**	***Dave Ray***	***Johannes Wibowo***	***Eileen Glynn***
Room 228	**TRACK 7**	Geotechnical instrumentation and foundation re-evaluation of John Day lock and Dam, Columbia River, Oregon-Washington	A study of the long term performance of seepage cutoff barriers in dams	Design, construction, and performance of seepage barriers for Guanella Dam, near Empire, CO	**TRACK 7**	Sensitive infrastructure sites and structures - Sonic drilling offers quality control and non-destructive advantages to geotechnical construction drilling	Subgrade failure criteria according to soil type and moisture condition	The automated stability monitoring of the Mississippi River levees using the range scan system
	Session 7G	***David Scofield***	***John Rice***	***John France***	**Session 7H**	***John Davis***	***Edel Cortez***	***Robert Jolissian***
Room 229	**TRACK 8**	Damaging interactions among concrete materials	Economic effects on construction of uncertainty in test methods	Major issues in materials specifications	**TRACK 8**	Spall and intermediate-sized repairs for PCC pavements	Acceptance criteria for unbonded aggregate road surfacing materials	Effective partnering to overcome an interruption in the supply of Portland cement during construction of Marmet lock and Dam
	Session 8G	***Toy Poole***	***Toy Poole***	***Toy Poole***	**Session 8H**	***Reed Freeman***	***Reed Freeman***	***Billy Neeley***

Break

Thursday, August 4, 2005 Concurrent Sessions

Geotechnical, Specifications, Electrical & Mechanical Engineering & Construction Tracks

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 225	**TRACK 9 Geotechnical**	Seepage Committee Meeting	Seepage Committee Meeting (Continued)	Seepage Committee Meeting (Continued)			
	Session 9E	***GROUP DISCUSSION***	***GROUP DISCUSSION***	***GROUP DISCUSSION***			
Room 232	**TRACK 21 Specifications**	SpecsIntact-Demonstration of the SI explorer, publishing to PDF and Word	SpecsIntact - Demonstration of the SI editor, UMRL and reference wizard	UFGS status and direction			
	Session 21E	***Patricia Robinson***	***Patricia Robinson***	***Jim Quinn***			
Room A	**TRACK 15 Military Electrical**	Electronic Security	Electronic Security (Continued)	AIRFIELD lightning protection & grounding and lighting			
	Session 15E	***Tri-Service Panel***	***Tri-Service Panel***	***Tri-Service Panel***			
Room B	**TRACK 16 Military Mechanical**	Lon works technology update	BACnet Technology Update	Implementation of Lon-based specifications			
	Session 16E	***David Schwenk***	***David Schwenk***	***Will White***			
Room D	**TRACK 17 Civil Mechanical**	Lessons learned on flood water pump stations	Armada of pump stations, Grand Forks and East Grand Forks	Various screen equipment selection guide			
	Session 17E	***Mark Robertson***	***Timothy Paulus***	***Sara Benier***			
Room 230	**TRACK 19 Construction**	NAVFAC Construction scheduling	NAVFAC Construction scheduling (Continued)	ACASS/CASS - CPARS			
	Session 19E	***Glenn Saito***	***Glenn Saito***	***Ed Marceau***			
Room 231	**TRACK 20 Construction**	Update on DAWIA and Facilities Engineering	Update on DAWIA and Facilities Engineering (Continued)	Partnering as a best practice			
	Session 20E	***Mark Grammer***	***Mark Grammer***	***Ray DuPont***			
				Break in Exhibit Hall			
Room 225					**TRACK 9 Geotechnical**	GMCoP Forum	GMCoP Forum (Continued)	GMCoP Forum (Continued)
					Session 9F	***GROUP DISCUSSION***	***GROUP DISCUSSION***	***GROUP DISCUSSION***
Room 232					**TRACK 21 Specifications**	UFGS transitin to Master-Format 2004	Project specifications for the upper tier Folsom outlet works modifications	UFGS dredging
					Session 21F	***Carl Kersten***	***Steve Freitas***	***Don Carmen***
Room A					**TRACK 15 Military Electrical**	Electrical safety and arc flash UFC	Electrical safety and arc flash UFC (Continued)	Electrical infrastructure in Iraq - Restore Iraqi electricity
					Session 15F	***Tri-Service Panel***	***Tri-Service Panel***	***Joseph Swiniarski***
Room B					**TRACK 16 Military Mechanical**	Prefabricated Chiller Plants	Seismic for ME systems	Design considerations for the prevention of mold
					Session 16F	***Trey Austin***	***Greg Stutts***	***Quinn Hart***
Room D					**TRACK 17 Civil Mechanical**	Lock gate replacement system	Lock gate replacement system (Continued)	Automated closure gate design for Duck creek flood control
					Session 17F	***Will Smith***	***Will Smith***	***Mark Robertson***
Room 230					**TRACK 19 Construction**	Self-consolidating concrete	Self-consolidating concrete (Continued)	
					Session 19F	***Beatrix Kerhoff***	***Beatrix Kerhoff***	
Room 231					**TRACK 20 Construction**	S&A Update	Construction Issues Open Forum (Q&A)	Construction Issues Open Forum (Q&A) (Continued)
					Session 20F	***Harry Jones***	***Don Basham***	***Don Basham***

12 Noon — **Lunch**

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM
Room 225	**TRACK 9 Geotechnical**	Seismic Manual	Seismic Manual (Continued)	Seismic Manual (Continued)			
	Session 9G	***GROUP DISCUSSION***	***GROUP DISCUSSION***	***GROUP DISCUSSION***			

Thursday, August 4, 2005 Concurrent Sessions

Dam Safety Track & Structural Engineering Track

	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:30 AM	11:00 AM	11:30 AM
Room 224	**TRACK 10** Dam Safety	Seepage and stability, final evaluation for reservoir pool raising project, Terminus Dam, Kaweah River, CA	Initial filling plan, Terminus dam spillway enlargement, Terminus Dam, Kaweah River, CA	Hydrologic aspects of operating in a "failure mode" - Fern Ridge Lake, OR			
	Session 10E	*Michael Ramsbotham*	*Michael Ramsbotham*	*Bruce Duffe*			
Room 240	**TRACK 12** Civil Works Structural	London lock and dam, West Virginia major rehabilitation project	Replacing existing lock 4-Innovative designs for Charleroi lock	Use of non-linear incremental structural analysis in the design of the Charleroi lock			
	Session 12E	*David Sullivan*	*Steveb Stoltz*	*Randy James*			
Room 241	**TRACK 13** Civil Works Structural	Chicago shoreline project	Structural assessment of Bluestone Dam	Duck Creek, OH local flood protection projection phase III Culvert damage			
	Session 13E	*Jan Plachta*	*Robert Reed*	*Jeremy Nichols*			
Room 242	**TRACK 14** Bridges/ Buildings	Urban search & rescue program overview	Evaluation and repair of blast damaged reinforced concrete beams	Single degree of freedom blast effects spreadsheets			
	Session 14E	*Tom Niedernhofer*	*John Hudson*	*Dale Nebuda*			
				Break in Exhibit Hall			
Room 224	**TRACK 10** Dam Safety				A dam safety study involving cascading dam failures		The relationship of seismic velocity to the erodibility index
	Session 10F				*Gordon Lance*		*Joseph Topi*
Room 240	**TRACK 12** Civil Works Structural				Olmsted dam in-the-wet construction methods	Completion of the Olmstead approach walls	John Day lock monolith repair
	Session 12F				*Lynn Raque*	*Terry Sullivan*	*Mathew Hanson*
Room 241	**TRACK 13** Civil Works Structural				Development of design criteria for the Rio Puerto Nuevo contract 2D/2E channel wall	Design of concrete lined tunnels in rock	Indianapolis north phase IIIA project
	Session 13F				*Jana Tanner*	*David Force*	*Gene Hoard*
Room 242	**TRACK 14** Bridges/ Buildings				UFC 4-023-02 Structural design to resist explosive effects for existing buildings	Progressive collapse UFC requirements	U.S. general services admnistrative progressive collapse design guidelines applied to concrete moment-resisting frame buildings
	Session 14F				*Jim Caulder*	*Brian Crowder*	*David Billow*

12 Noon — **Lunch**

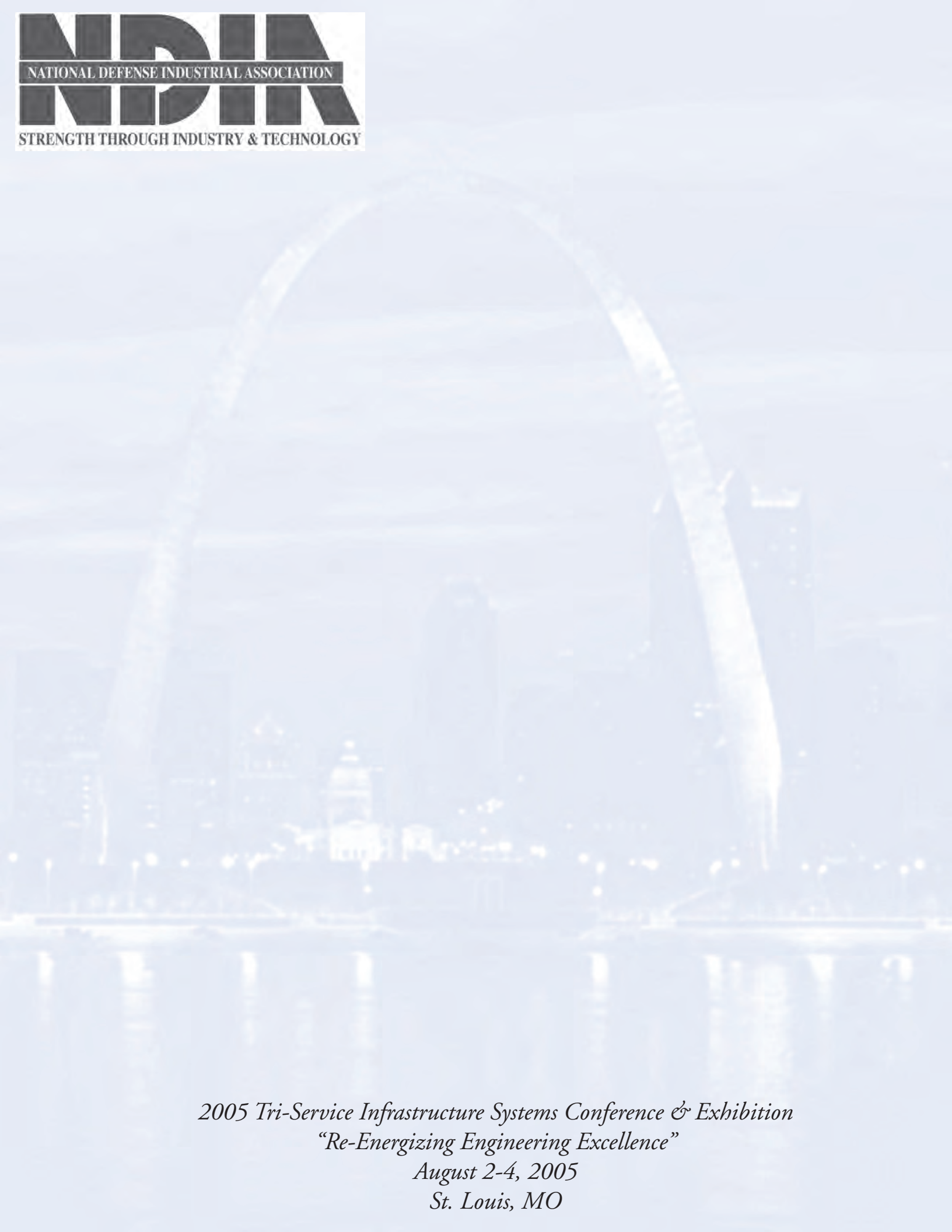
	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM
Room 224	**TRACK 10** Dam Safety	Dam safety instrumentation data management utilizing WinIDP to aid data collection and evaluation	Automated instrumentation assessments at Marmet lock & Dam	Potential failure mode analysis of Eau Galle Dam			
	Session 10G	*Travis Tutka*	*Ronald Rakes*	*David Rydeen*			
Room 240	**TRACK 12** Civil Works Structural	Inner Harbor navigation canal and lock structure	Design features and challenges of the Comite River diversion project	Waterline support failure on the Harvey canal: A case study			
	Session 12G	*Mark Gonski*	*Christopher Dunn*	*Angela DeSoto Duncan*			
				Break			
Room 224	**TRACK 10** Dam Safety				Dam safety officers panel - The Good	Dam safety officers panel - The Bad	Dam safety officers panel - The Ugly
	Session 10H				*Bruce Murray*	*Bruce Murray*	*Bruce Murray*
Room 240	**TRACK 12** Civil Works Structural				Public appeal of major civil projects- The good, the bad and the ugly	Des Moines Riverwalk	Chickamauga lock and Dam height optimization study using Monte Carlo simulation
	Session 12H				*Kevin Holden*	*Thomas Heinold*	*Leon Schieber*

Thursday, August 4, 2005 Concurrent Workshops

	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM
Room 241	**Workshop 1** DoD Security Engineering	Security planning & minimum standards	Security planning & minimum standards (Continued)	Security planning & minimum standards (Continued)	Security design manuals	Security design manuals (Continued)	Security design manuals (Continued)
	Session 1A	*Curt Betts*	*Curt Betts*	*Curt Betts*	**Session 1B**	*Bernie Deneke*	*Bernie Deneke*	*Bernie Deneke*
Room 231	**Workshop 2** Electrical Workshop	National Electrical Code 2005 Changes	National Electrical Code 2005 Changes (Continued)	National Electrical Code 2005 Changes (Continued)	National Electrical Code 2005 Changes (Continued)	National Electrical Code 2005 Changes (Continued)	National Electrical Code 2005 Changes (Continued)
	Session 2A	*Mark McNamara*	*Mark McNamara*	*Mark McNamara*	**Session 2B**	*Mark McNamara*	*Mark McNamara*	*Mark McNamara*
Room 242	**Workshop 3** Mechanical Engineering	Design and application of packaged central cooling plants	Design and application of packaged central cooling plants (Continued)	Design and application of packaged central cooling plants (Continued)	Improving dehumidification in HVAC systems	Improving dehumidification in HVAC systems (Continued)	Improving dehumidification in HVAC systems (Continued)
	Session 3A	*The Trane Company*	*The Trane Company*	*The Trane Company*	**Session 3B**	*The Trane Company*	*The Trane Company*	*The Trane Company*
Room 230	**Workshop 4** Construction	Construction Community of Practice Forum	Construction Community of Practice Forum (Continued)	Construction Community of Practice Forum (Continued)			
	Session 4A	*Walt Norko*	*Walt Norko*	*Walt Norko*			
Room 232	**Workshop 5** Specifications	Open Meeting of Corps Specifications Steering Committee	Open Meeting of Corps Specifications Steering Committee (Continued)	Open Meeting of Corps Specifications Steering Committee (Continued)	Open Meeting of Corps Specifications Steering Committee (Continued)	Open Meeting of Corps Specifications Steering Committee (Continued)	Open Meeting of Corps Specifications Steering Committee (Continued)
	Session 5A	*Robert Iseli, et al.*	*Robert Iseli, et al.*	*Robert Iseli, et al.*	**Session 5B**	*Robert Iseli, et al.*	*Robert Iseli, et al.*	*Robert Iseli, et al.*

Break

NOTES



2005 Tri-Service Infrastructure Systems Conference & Exhibition
"Re-Energizing Engineering Excellence"
August 2-4, 2005
St. Louis, MO

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Walla Walla District
Northwestern Division



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McNary Dam Levee System (Tri-Cities Levees) Columbia River, Washington



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McNary Dam Levee System (Tri-Cities Levees)

- The McNary levees were constructed in lieu of moving the downtown business areas of Kennewick, Pasco, and Richland Washington.
- The levees were constructed in 1952, prior to the completion of McNary Lock and Dam on the Columbia River in 1953.
- McNary dam reservoir created a 38 mile backwater pool upstream to these cities.

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McNary Lock & Dam
Columbia River
Oregon & Washington



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McNary Dam Levee System (Tri-Cities Levees)

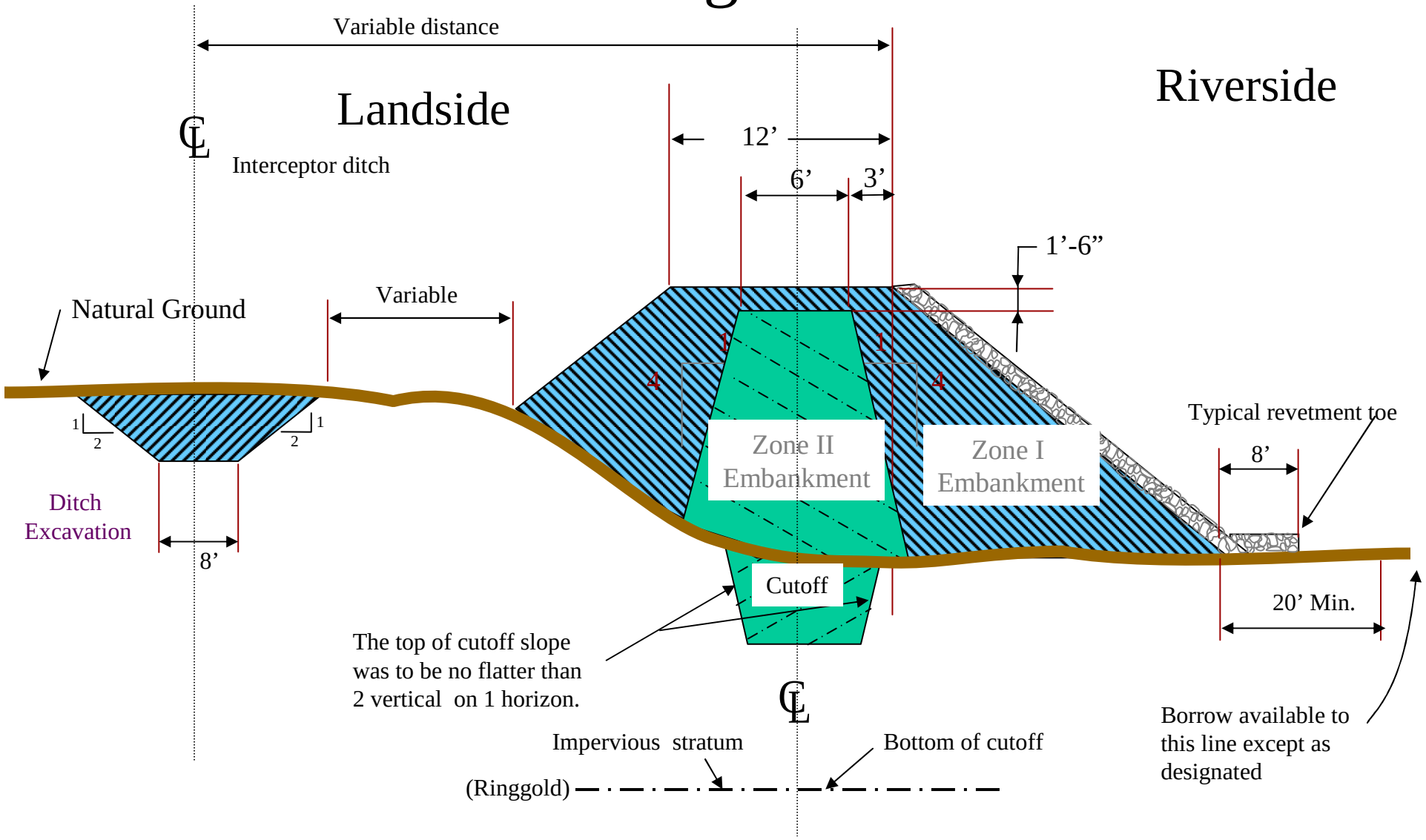
•The Standard Project Flood (SPF) was based on an unregulated flood of record of 840,000 cfs that occurred in 1894.

•That flood plus levee free board was used as the levee design height.

•Urban levees were designed to a height of 8 feet above the SPF and rural levees were designed to a height of 5 feet above the SPF.

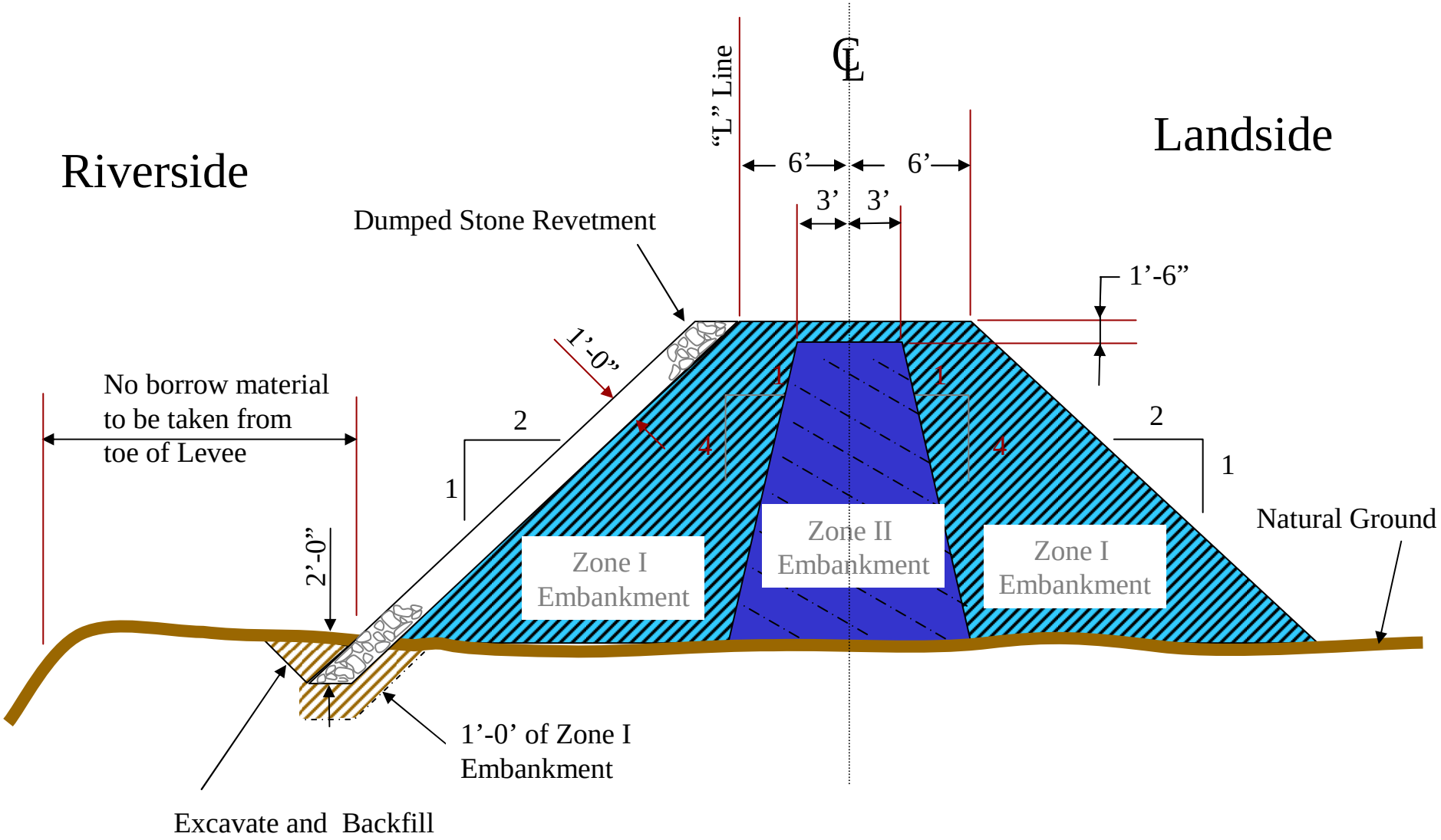
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Typical Levee Section with a Foundation Cutoff and Drainage Ditch



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Typical Levee Section Without a Cutoff



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Tri-Cities Levees Construction – 1952



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Tri-Cities Levees Construction – 1952





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U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT





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Walla Walla District

McNary Dam Levee System (Tri-Cities Levees)

- On going since 1984 the old North Pacific Division completed a Final Report dated June 1991 entitled “Review of Flood Control, Columbia River Basin; Columbia River and Tributaries Study CRT -63”.
- This study was to consider the impacts of the present upstream reservoir storages has had in lowering water surface elevations during major floods.
- The study was also a recommendation in the Northwest Power Planning Council Fish and Wildlife Program due to ESA issues.

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McNary Dam Levee System (Tri-Cities Levees)

- A Reconnaissance Report, driven by local and congressional interest, was completed in May 1992 by the District. This report was to see if there was any federal interest in lowering and/or beautifying the levees.
- Although the study provided a new regulated Standard Project Flood (SPF) of 512,000 cfs, above the Snake River showing that some of the levees were constructed with as much as 10 to 12 feet of freeboard, it also showed that there was no federal interest in lowering or beautifying them.

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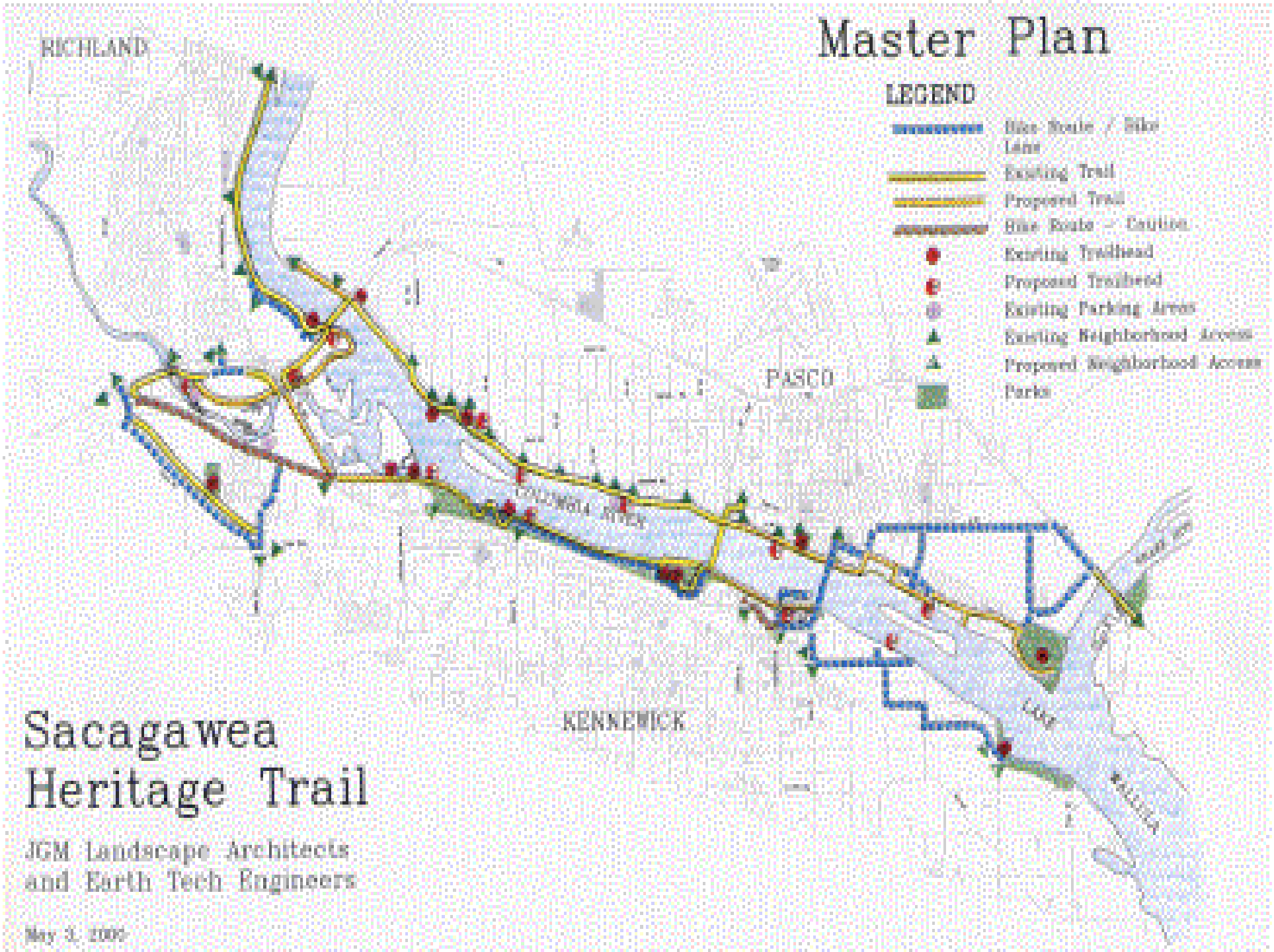
McNary Dam Levee System (Tri-Cities Levees)

- From 1992 to 2004, local stakeholders looked for ways to get the levees lowered with federal funding.
  - A coordination group called the Tri-Cities Rivershore Enhancement Council (TREC) was formed.
  - local governments continued to lobby their congressional for legislative action.
  - As a group they were successful in getting verbiage in the Water Resource Development Act of 1996 “WRDA 96”.
  - WRDA 96 language required the District to turn over the lands but the District was to keep the operation & maintenance responsibilities. The locals found out that they had to fund some of the transfer costs including addressing Cultural Resources and opted out.

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McNary Dam Levee System
Tri-Cities Levees

- Local stakeholders then tried to achieve levee lowering via the Corps Continuing Authority Program (CAP), looking at a General Investigation study as well as several 1135 studies. When the sponsor saw how much this would cost, they opted not to pursue this route.
- The locals began working with the District on how to change the Corps Standard Parks and Recreation Lease into a Non-standard Parks and Recreation Lease.
- The locals were finally successful with the lease culminating with the District Commander and other local dignitaries formally signing the lease at a ceremony in 2004.


Master Plan
LEGEND
Bike Route / Bike Lane
Existing Trail
Proposed Trail
Bike Route - Caution
Existing Trailhead
Proposed Trailhead
Existing Parking Areas
Existing Neighborhood Access
Proposed Neighborhood Access
Parks
RICHLAND
PASCO
KENNEWICK
Sacagawea Heritage Trail
JGM Landscape Architects and Earth Tech Engineers
May 3, 2005

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Sacagawea Heritage Trail Levee 12-1

The City of Pasco through a Parks and Recreation lease was allowed to lower portions of Levee 12-1 (6400 lf) approximately 6 feet, including Pump Plant 12-1 and 12-1A piping and filling in some of the levee drainage ditch by installing a 78-inch perforated drainage pipe to provide better access to the levee. They also constructed a paved trail, along with some benches and landscape improvements for approximately $1.4 million in 2004/2005. They were also required to install a new 200 hp pump in pump plant 12-1A to mitigate loss of flood storage.

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Levee 12-1



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Levee 12-1



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Levee 12-1



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Levee 12-1



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Levee 12-1



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Levee 12-1



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Lowered Levee 12-1



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Levee 12-1A Pump Plant and Piping



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Levee 12-1A Pump Plant and Piping



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Levee 12-1 Levee Access from Rivershore Park



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Levee 12-1 Levee Access from Rivershore Park



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Levee 12-1
Eyebrow Planter



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Levee 12-1 Landscape Irrigation Valve



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Levee 12-1
Pump Plant 12-1A



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Levee 12-1/Pump Plant 12-1A New 200 hp Pump



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Levee 12-1 Road 25
Levee Access



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Levee 12-1



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Sacagawea Heritage Trail Levee 5D

The City of Kennewick through their Parks and Recreation Lease was allowed to lower portions of Levee 5D approximately 6 feet (7900 lf), including lowering Pump Plant 5D piping and filling in the upstream portion of the levee's drainage ditch by installing a 42-inch perforated drainage pipe. They constructed a paved trail on top of the levee, along with other amenities such as benches and covered picnic tables along with landscape improvements for approximately $1.7 million in 2004/2005.

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Levee 5D



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Levee 5D Drainage Ditch



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Levee 5D



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Walla Walla District

Levee 5D



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Walla Walla District

Levee 5D Drainage Ditch



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Levee 5D Drainage Ditch



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Levee 5D Pump Plant Piping



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Levee 5D Pump Plant Piping



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Levee 5D New Irrigation for Landscaping



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Levee 5D New Irrigation for Landscaping



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Lowered Levee 5D



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Walla Walla District

Levee 5D Pump Plant 5D



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Walla Walla District

Levee 5D Landscaping



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Walla Walla District

Levee 5D Landscaping sign for Irrigation



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Walla Walla District

Levee 5D Landscaping



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Walla Walla District

Levee 5D Drainage Ditch



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Walla Walla District

Levee 5D
Surface Drainage Ditch



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Levee 5D
Surface Drainage Ditch



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McNary Dam Levee System Tri-Cities Levees Sacagawea Heritage Trail

This is a success story of how the Walla Walla District helped two communities, located across the Columbia River from each other, find a way to lower existing flood control levees, allowing the general public access to and use of the riverfront and still maintain the protective function of the levees.

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QUESTIONS

Internal Erosion & Piping at Fern Ridge Dam

Jeremy Britton
U. S. Army Corps of Engineers
Portland District

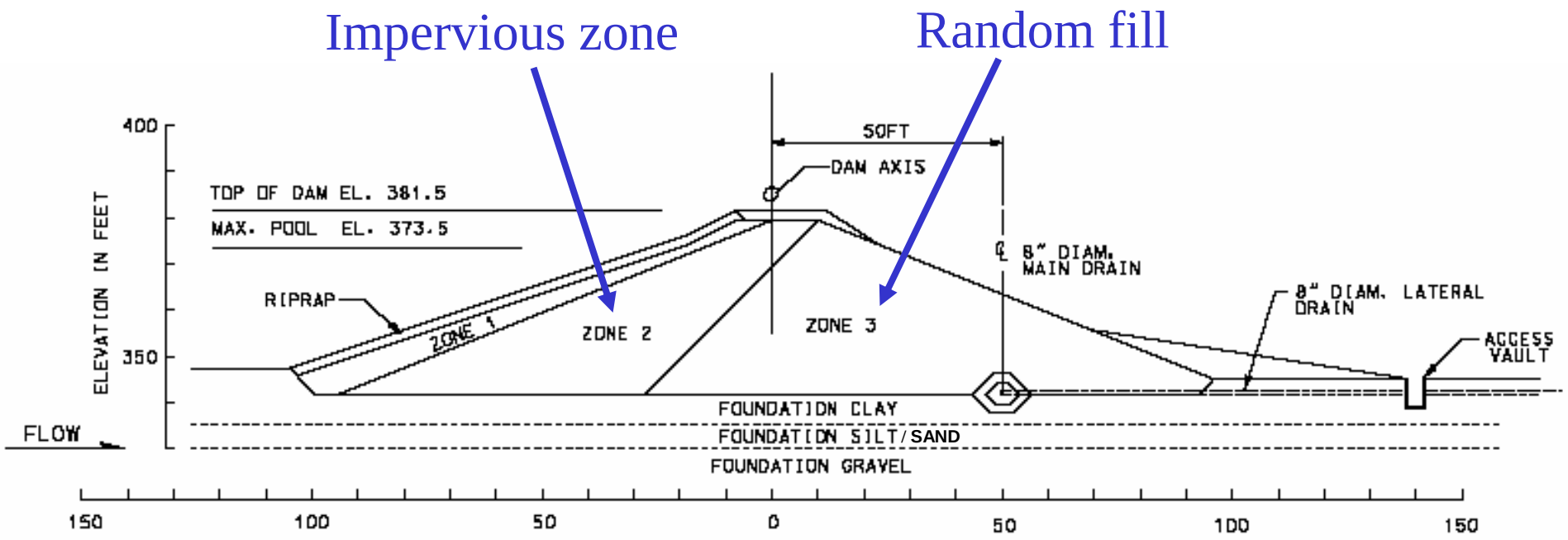
Project Location

Fern Ridge Project



FERN RIDGE DAM




Impervious zone
Random fill
400
350
ELEVATION IN FEET
TOP OF DAM EL. 381.5
MAX. POOL EL. 373.5
RIPRAP
ZONE 1
ZONE 2
ZONE 3
50FT
DAM AXIS
℄ 8" DIAM.
MAIN DRAIN
8" DIAM. LATERAL
DRAIN
ACCESS
VAULT
FLOW
FOUNDATION CLAY
FOUNDATION SILT/SAND
FOUNDATION GRAVEL
150
100
50
0
50
100
150

TWO PROBLEMS

1) Internal Erosion & Piping
   – Current Repair

2) Liquefaction in the Foundation Silty Sand

OBSERVATIONS OF DISTRESS IN LAST 3 YEARS

Depressions on downstream slope (3)

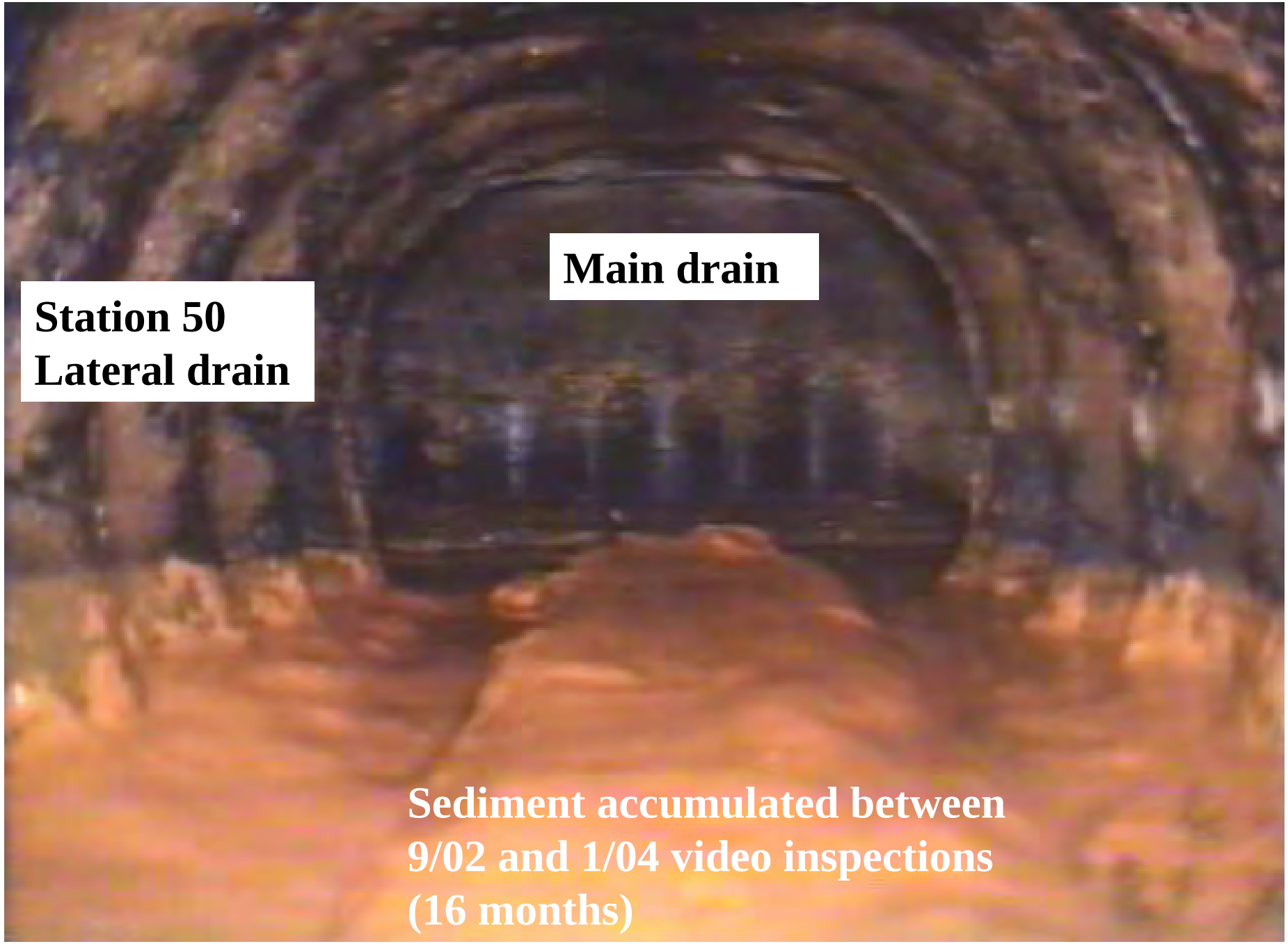
- 5 – 20 ft in diameter, 8 – 12 inches deep

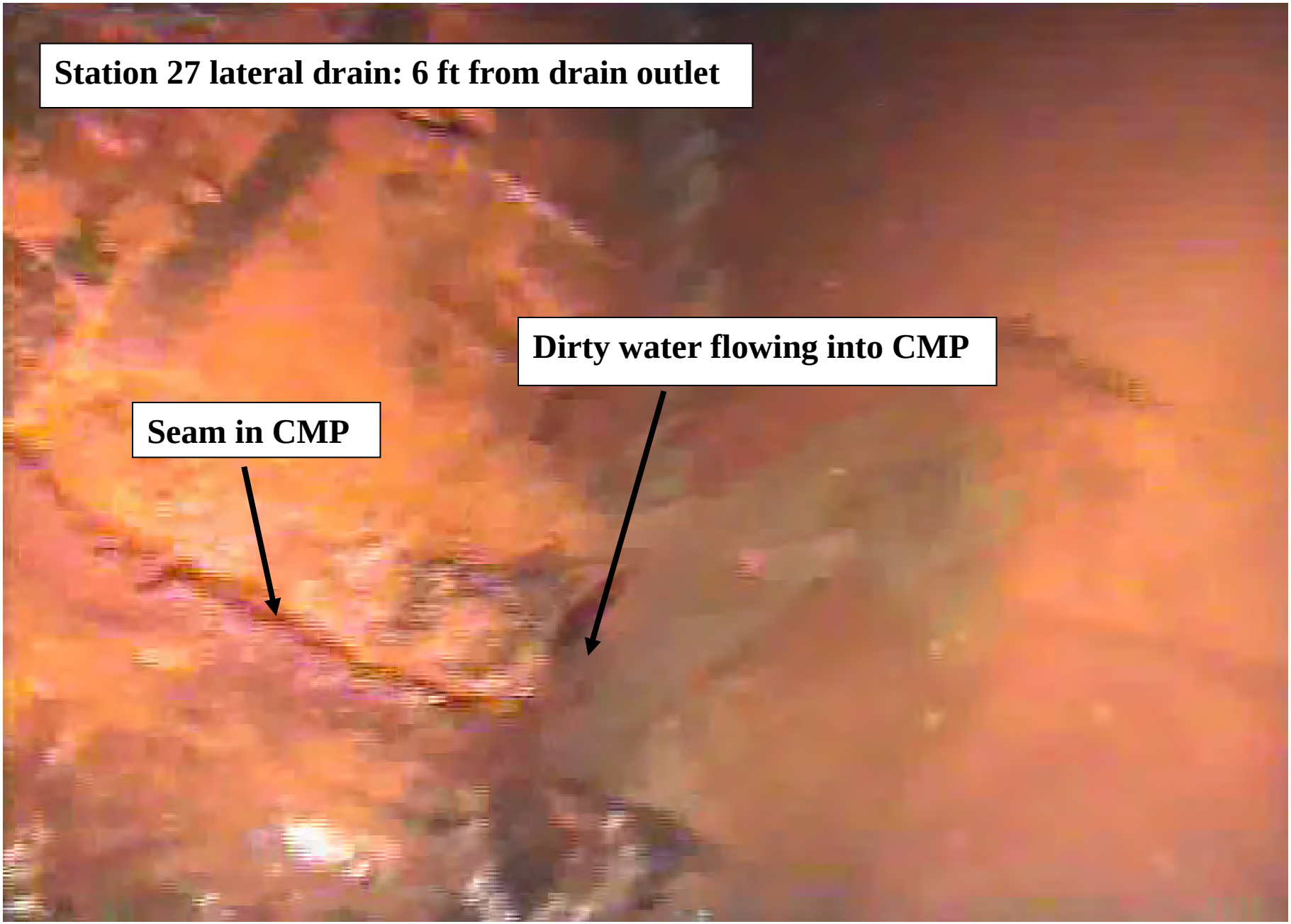
Spikes in lateral drain flows during rain events

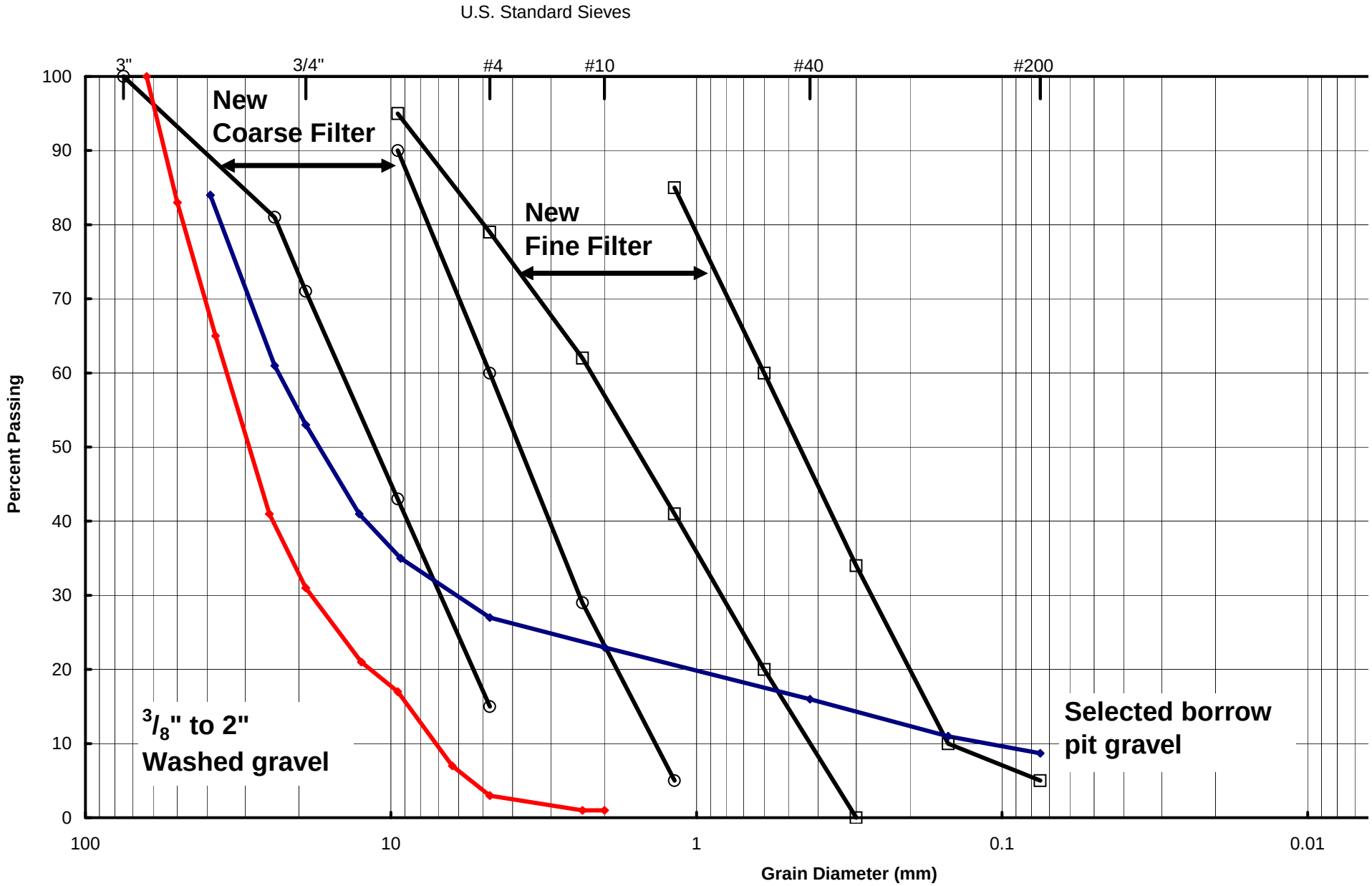
- Normal summer flows: trickle to 4 gpm *
- Heavy rains cause spikes of up to 10 gpm

Sediment transport in lateral drains

- Several drains carry clay, silt, and sand
- * Sta. 45: normal flow = 7 – 10 gpm; 5 – 10 lbs per month accumulating behind weir [15% organics, 55% fines (MH), 30% sand]


Main drain
Station 50
Lateral drain
Sediment accumulated between
9/02 and 1/04 video inspections
(16 months)


Station 27 lateral drain: 6 ft from drain outlet
Dirty water flowing into CMP
Seam in CMP


U.S. Standard Sieves
3"
3/4"
#4
#10
#40
#200
100
90
80
70
60
50
40
30
20
10
0
Percent Passing
New
Coarse Filter
New
Fine Filter
3/8" to 2"
Washed gravel
Selected borrow
pit gravel
100
10
1
0.1
0.01
Grain Diameter (mm)

Selected borrow pit gravel

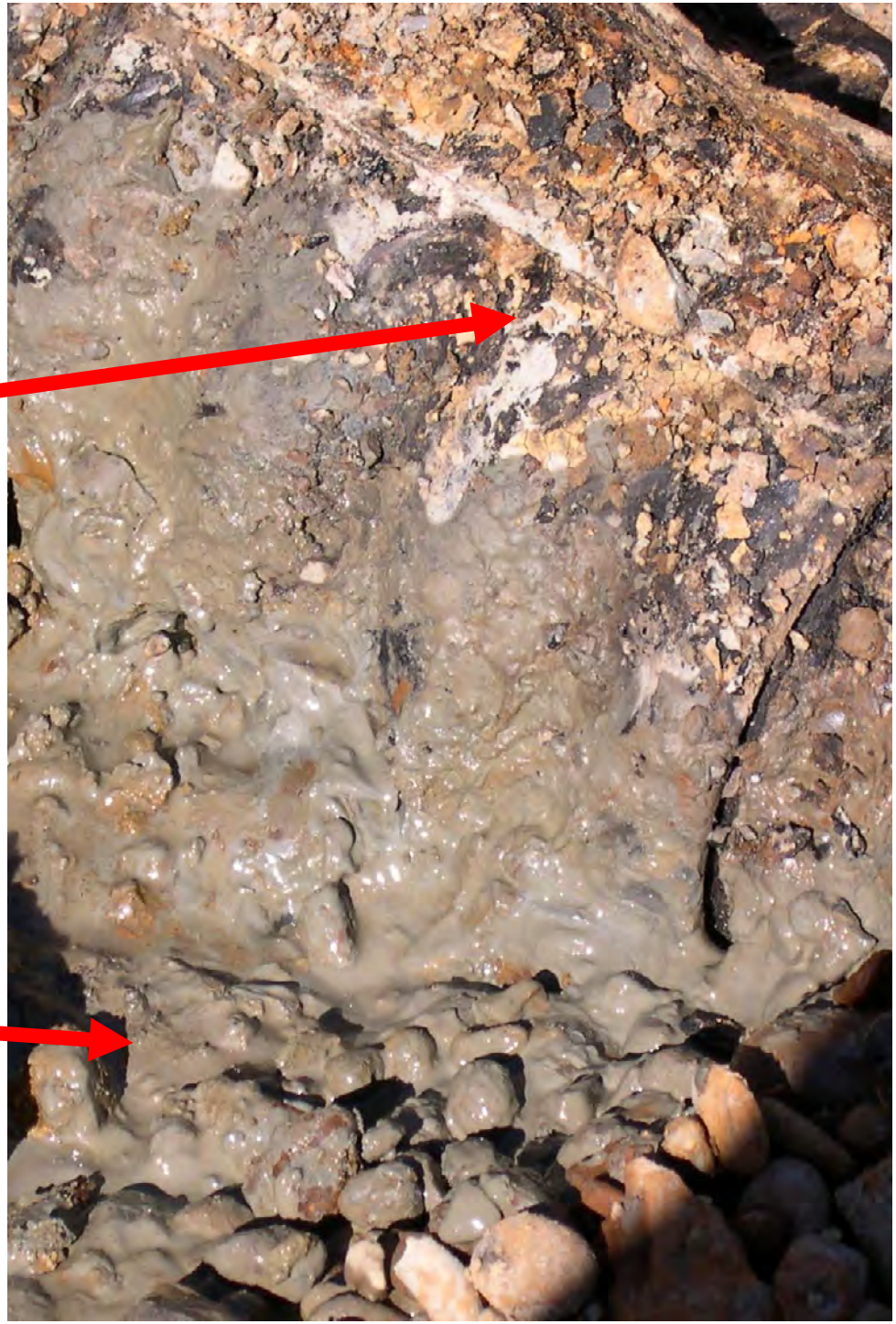


$^{3}/_{8}$” to 2” Washed gravel

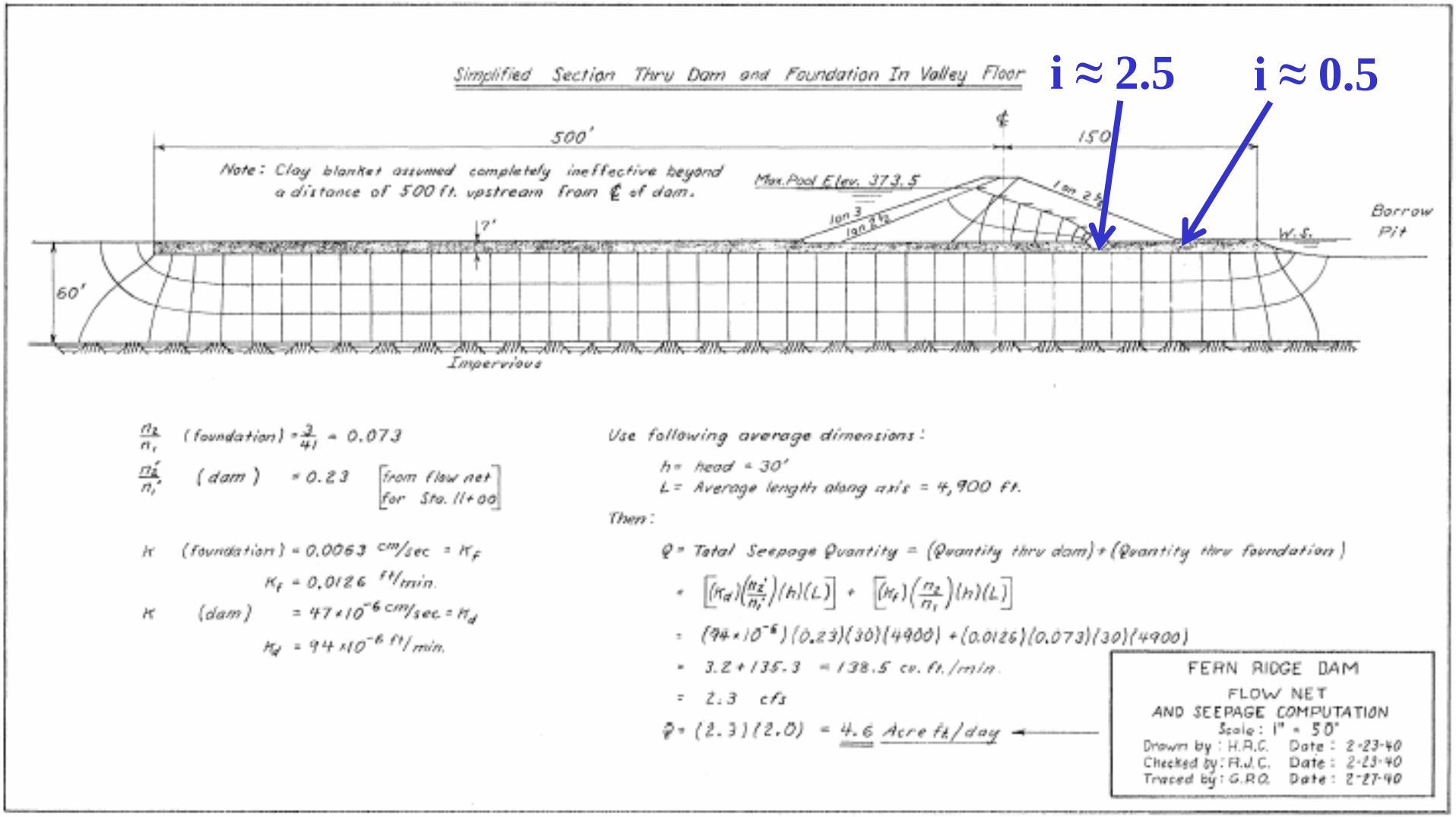


Lateral drain coupling band

$^{3}/_{8}$” to 2” Washed gravel

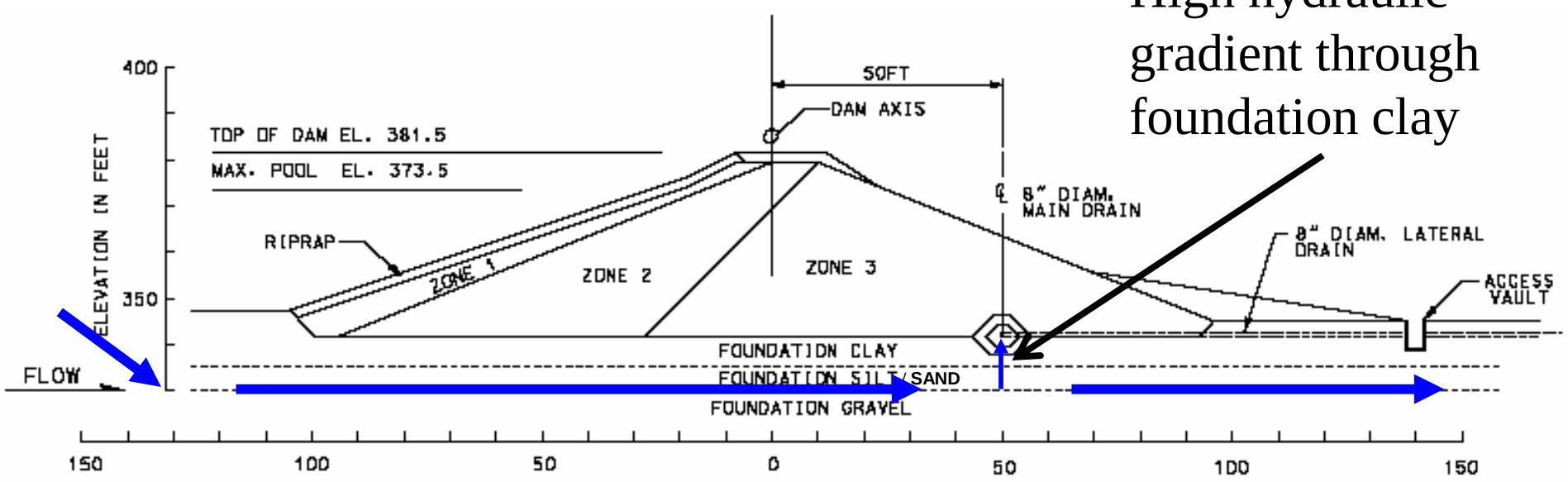


Original design flow net drawn by Cedergren in 1940



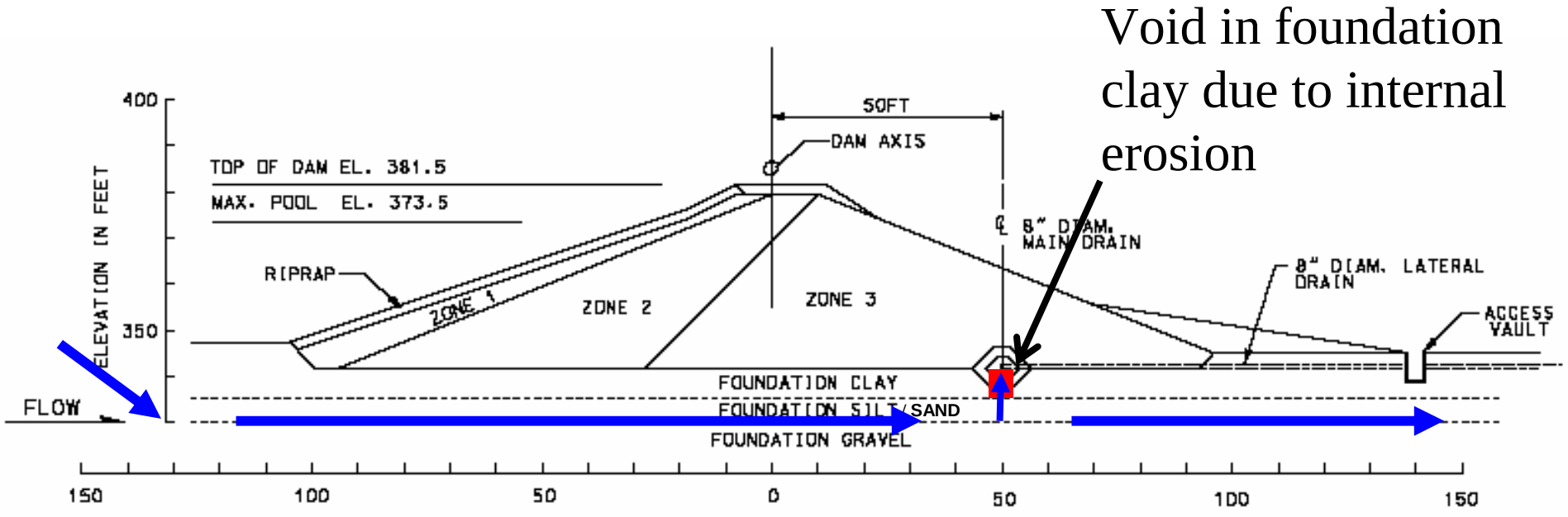
FEM seepage analysis of existing conditions: i ≈ 1 at toe of disposal zone

Piping in Foundation Silty Sand



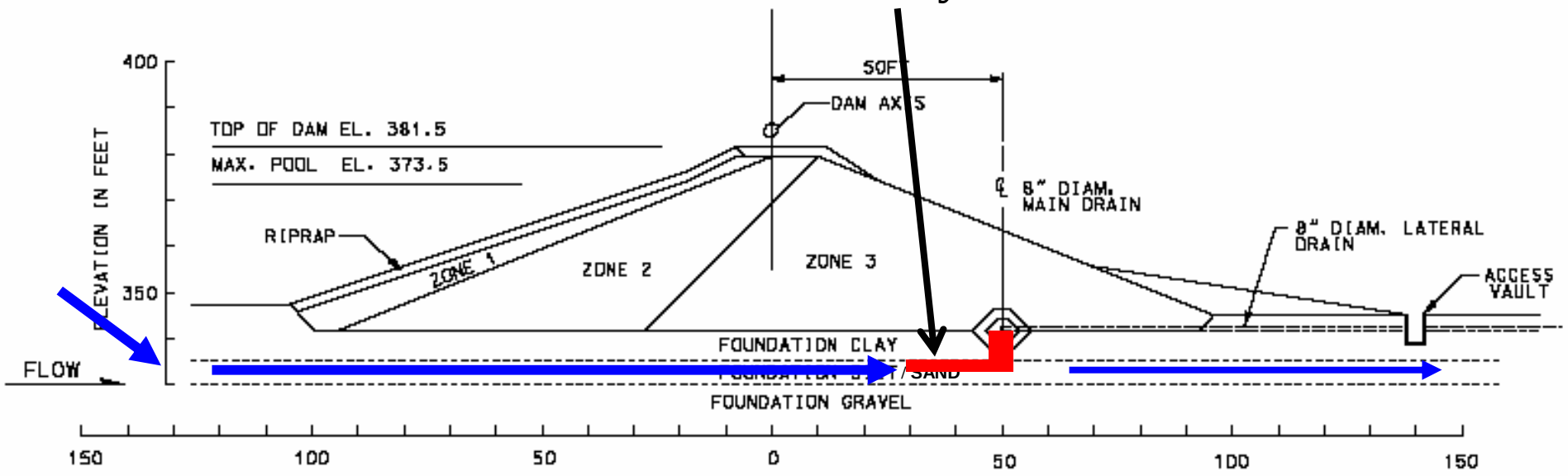
Foundation seepage to Kirk Pond

Piping in Foundation Silty Sand



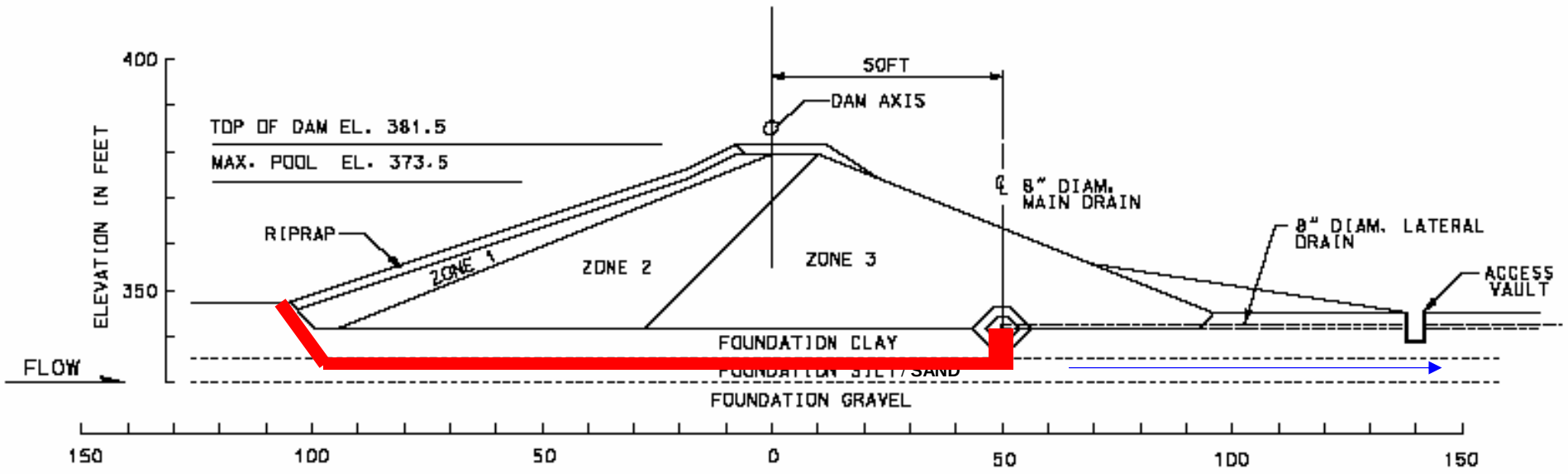
Piping in Foundation Silty Sand

Pipe develops
in silty sand



Flow rate increases due
to shortening flow path

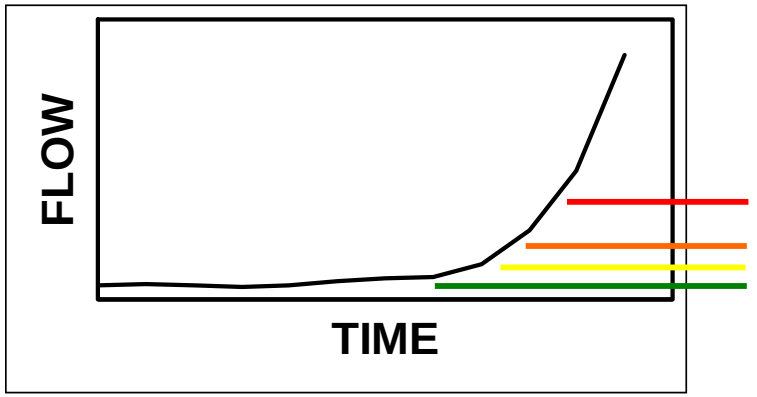
Piping in Foundation Silty Sand



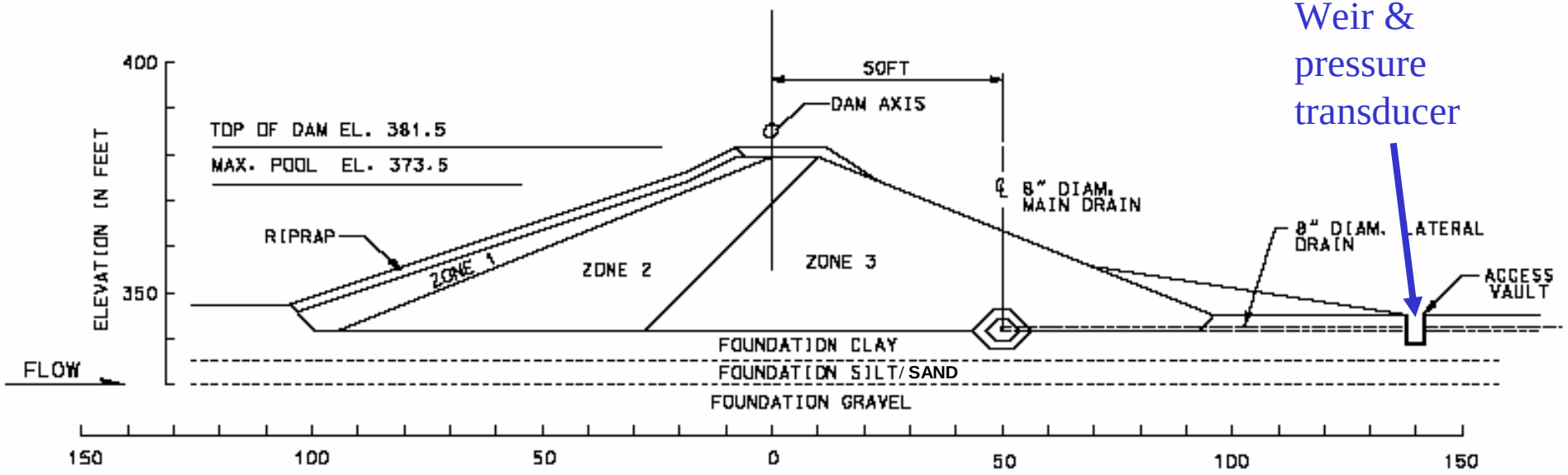
Pipe reaches lake. Flow rate and erosion accelerate rapidly

Event Alert System

* Lookout Point Control Room
* Fern Ridge Project
* Portland District Office



Weir & pressure transducer



Senior Review Board (12/04)

- Francke Walberg, URS (retired from Corps)
- Jim Talbot, retired from SCS
- Keith Ferguson, Kleinfelder

➢ "Active state of failure by piping and/or internal erosion"

➢ "District's focus should be immediately shifted from investigations and evaluation to development and implementation of corrective actions"

Station 14+40

At Pool Elev 373.5 (Max. Cons. Pool)

For Foundation Piping/Erosion FM

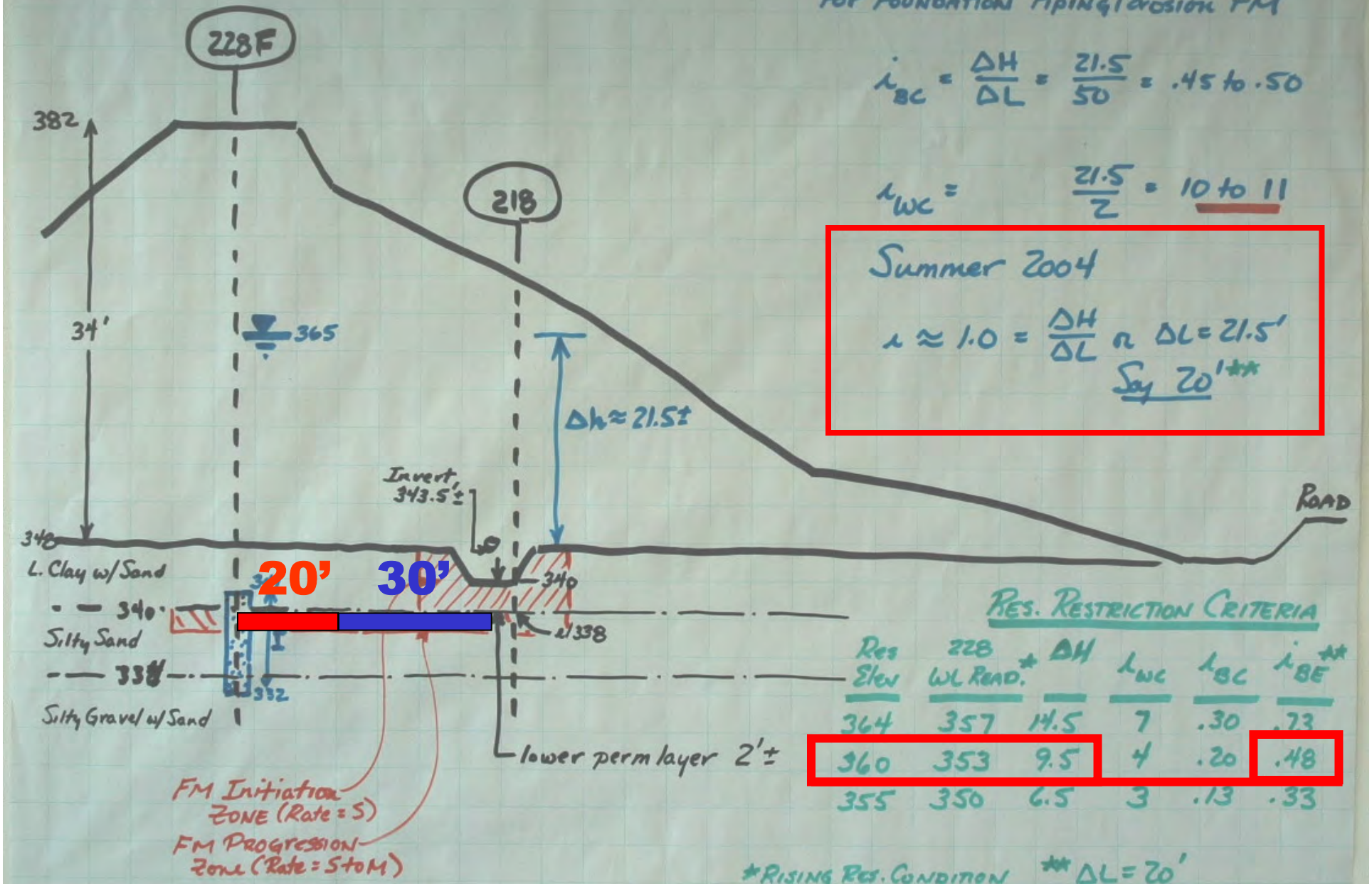
$i_{BC} = \frac{\Delta H}{\Delta L} = \frac{21.5}{50} = .45$ to $.50$

$i_{WC} = \frac{21.5}{2} = 10$ to 11

Summer 2004

$i \approx 1.0 = \frac{\Delta H}{\Delta L}$ n $\Delta L = 21.5'$

Say $20'$**



Res. Restriction Criteria

Res Elev	228 WL Read.*	ΔH	i_{WC}	i_{BC}	i_{BE}**
364	357	14.5	7	.30	.73
360	353	9.5	4	.20	.48
355	350	6.5	3	.13	.33

*Rising Res. Condition ** $\Delta L = 20'$

PROJECT BENEFITS

Flood Control

- $400M in damages prevented over 60 years
- $80M in 1996 flood
- Over $40M in 1997 and 1999 floods

Irrigation (Annual Benefit)

- Direct: $165k (water service contracts)
- Indirect: $1.5M to $2.9M (agricultural products)

PROJECT BENEFITS

Recreation (Sailing, Marinas, Campgrounds)

- 600,000 visitors per year
- $5M in local benefits, $3.5M in indirect benefits

Environmental

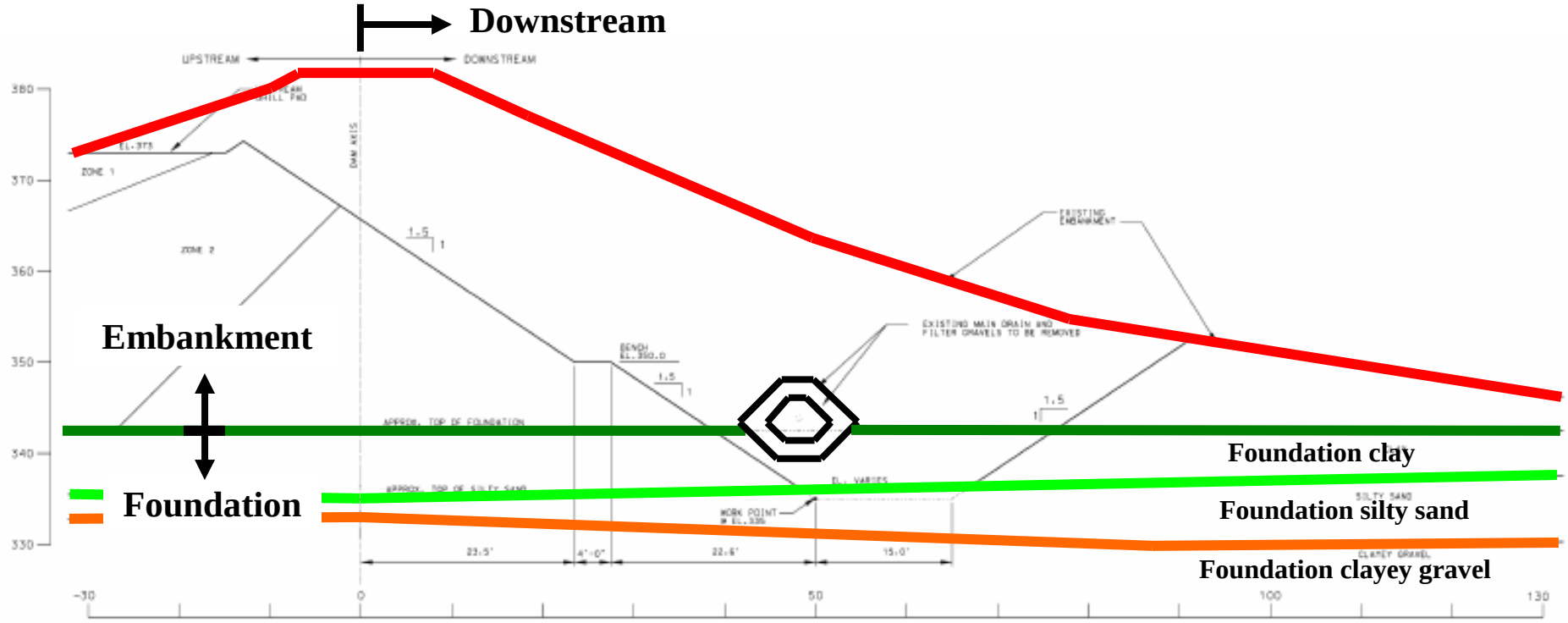
- Sect. 1135 restoration projects, Waterfowl nesting habitat, Warm water fisheries, Shoreline riparian habitat

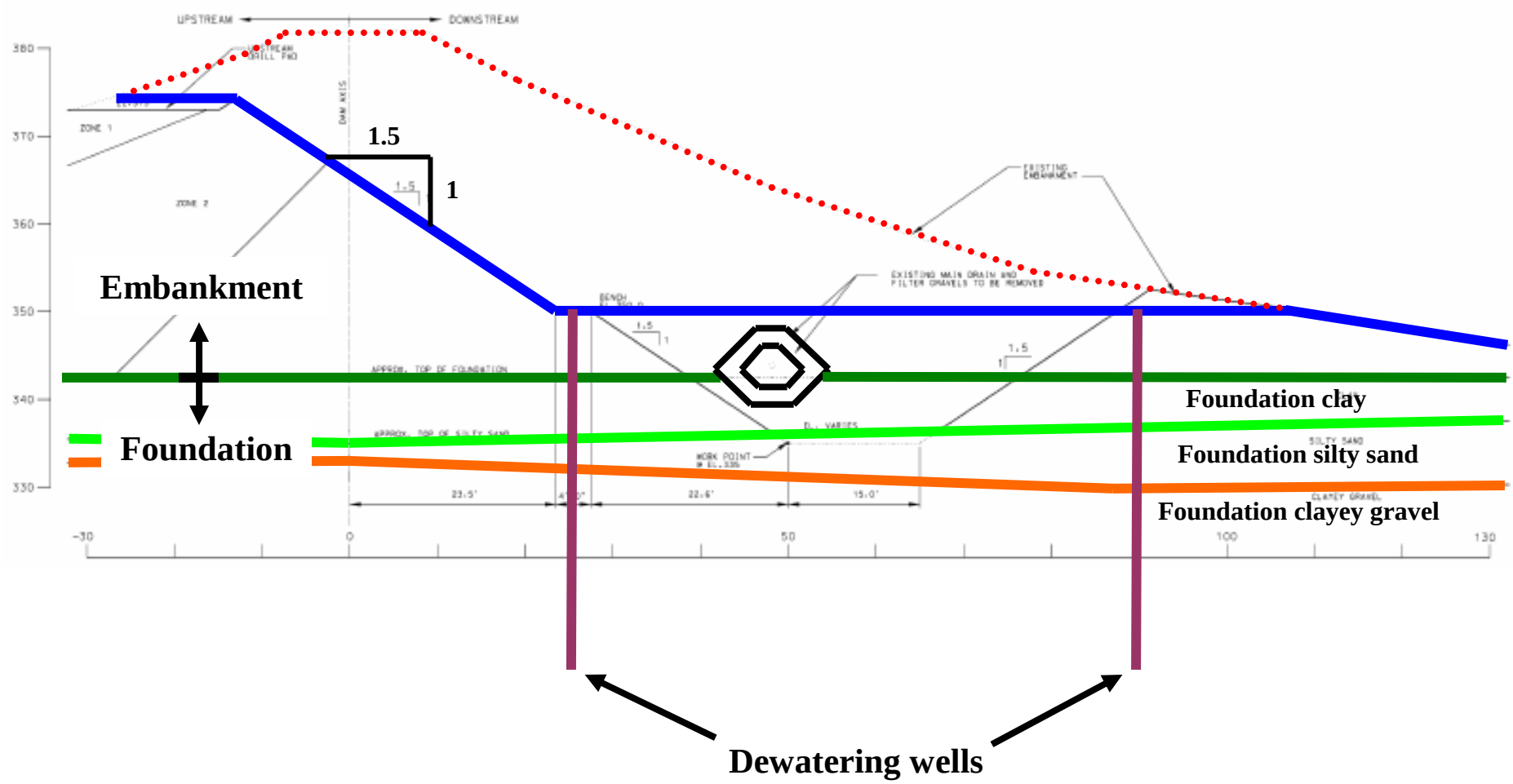
SCHEDULE

- Senior review board Dec 2004
- Decision to repair Feb 10, 2005
- Awarded contract May 13, 2005
- Construction began June 1, 2005
- Complete main construction Oct 15, 2005
- Be ready for flood control season Nov 1, 2005

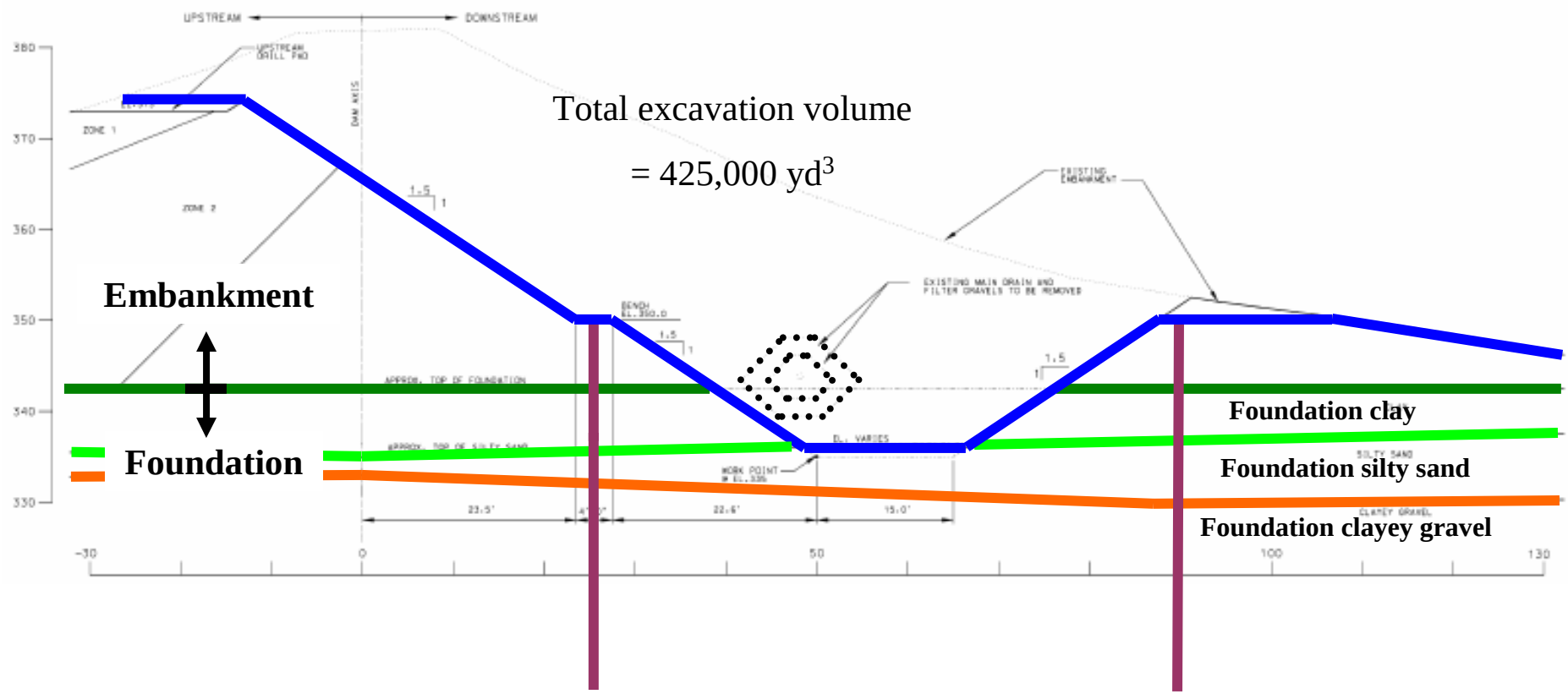
Design Goals

- Constructible in 5 – 6 months
- Remove failing drainage system and repair any small voids/erosion channels (if we have to repair large features, construction will exceed 6 months)
- New drain: collect embankment and foundation seepage
- Leave room for a potential seismic repair

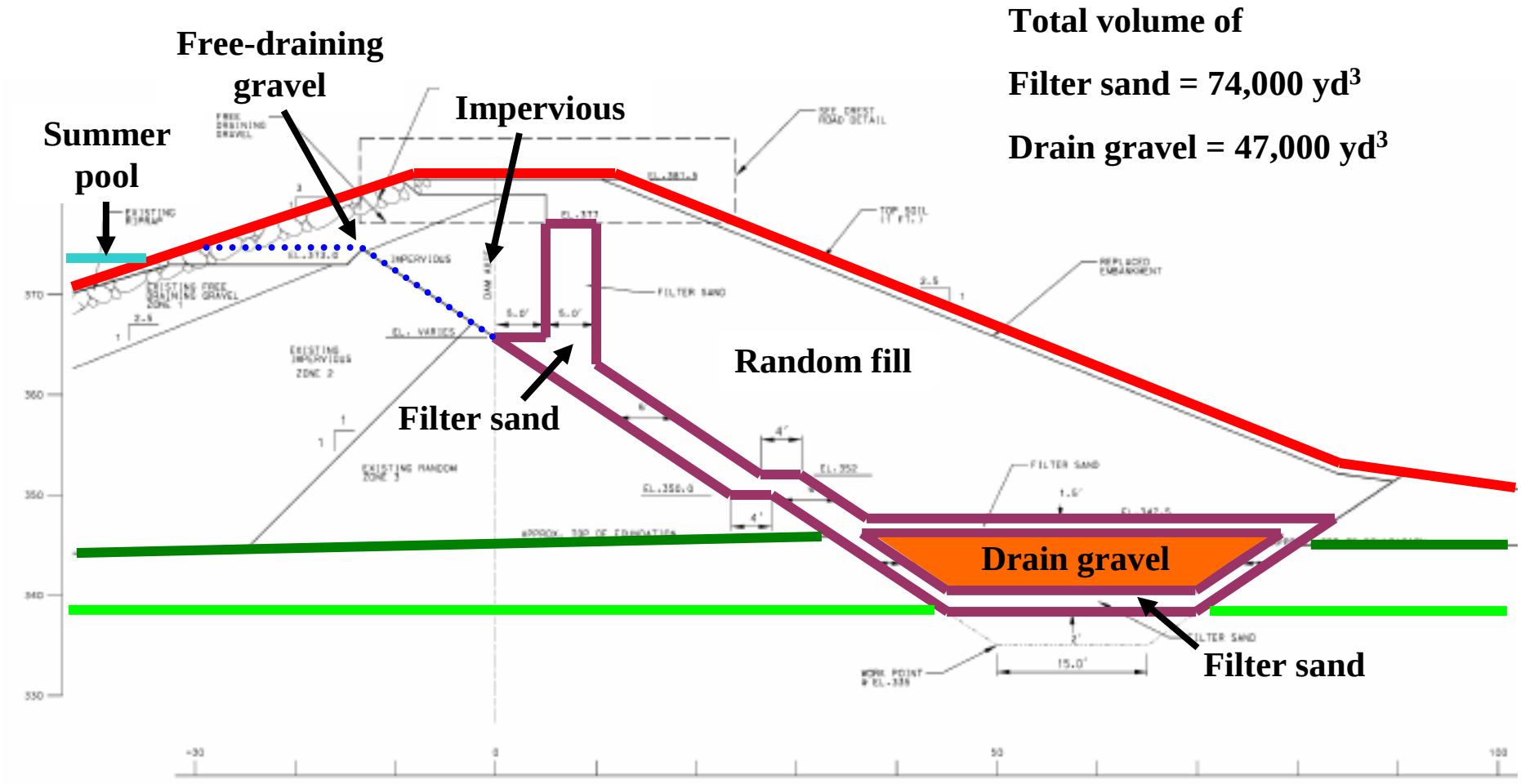

Downstream
UPSTREAM
DOWNSTREAM
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
APPROX. TOP OF FOUNDATION
EXISTING MAIN DRAIN AND FILTER GRAVELS TO BE REMOVED
EXISTING EMBANKMENT
BENCH EL.350.0
WORK POINT @ EL.336
ZONE 1
ZONE 2
DAM AXIS
380
370
360
350
340
330
-30
0
50
100
130


UPSTREAM
DOWNSTREAM
1.5
1
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
Dewatering wells


CAT


Total excavation volume
= 425,000 yd3
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
UPSTREAM
DOWNSTREAM
APPROX. TOP OF FOUNDATION
BENCH EL. 350.0
EXISTING MAIN DRAIN AND FILTER GRAVELS TO BE REMOVED
WORK POINT @ EL. 339
23.5'
22.6'
15.0'
380
370
360
350
340
330
-30
0
50
100
130


CAT
CAT 349E


Free-draining gravel
Impervious
Summer pool
Random fill
Filter sand
Drain gravel
Filter sand
Total volume of
Filter sand = 74,000 yd3
Drain gravel = 47,000 yd3

Design, Construction and Seepage at Prado Dam

Douglas E. Chitwood, P.E., G.E.
Embankment Engineer, Prado Dam

SANTA ANA RIVER MAINSTEM PROJECT

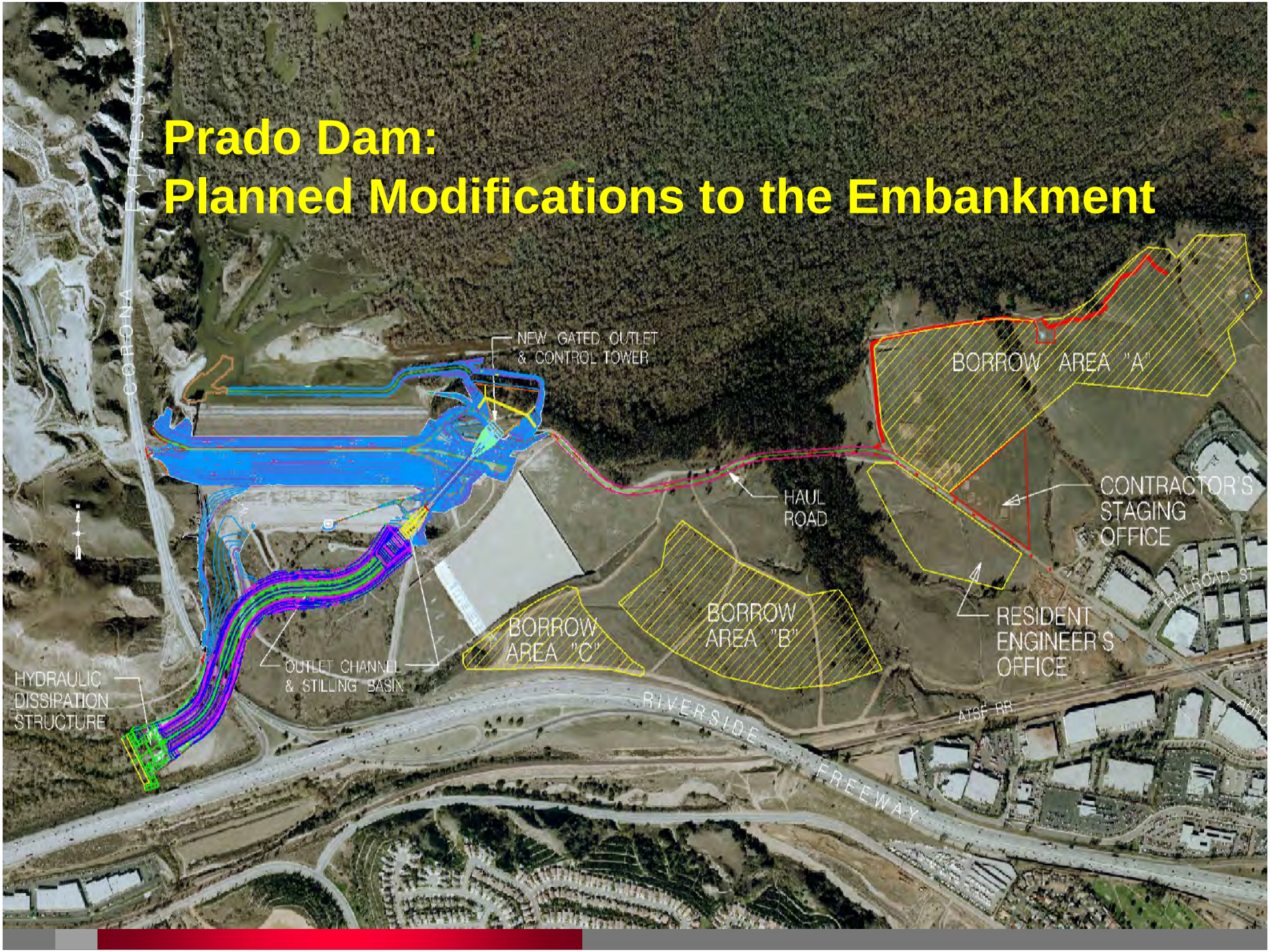
PROJECT MAP



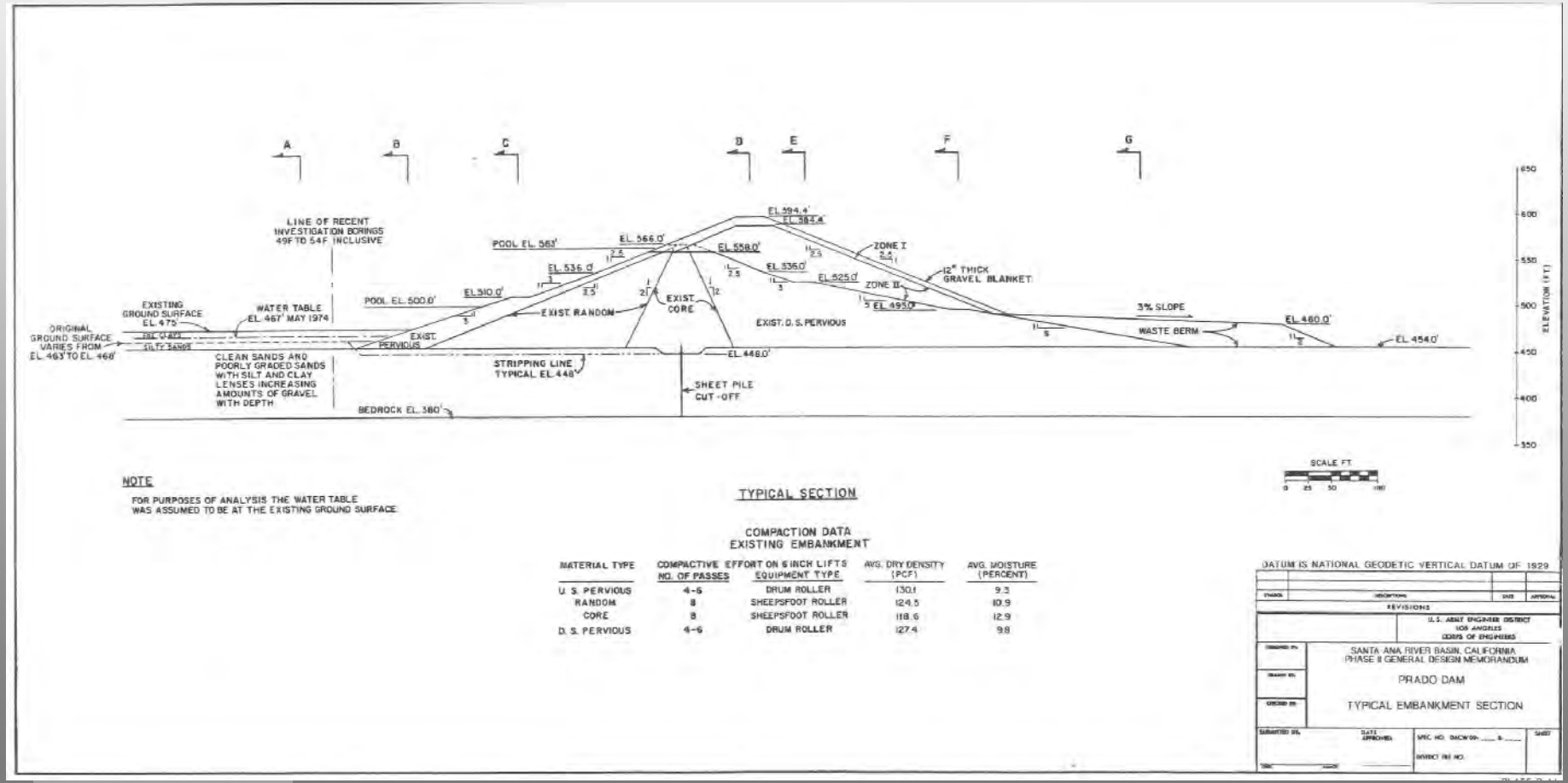
SAR Mainstem


Prado Dam
(after
Modifications)

Prado Dam:
Planned Modifications to the Embankment



Original Embankment: Typical Section



NOTE

FOR PURPOSES OF ANALYSIS THE WATER TABLE WAS ASSUMED TO BE AT THE EXISTING GROUND SURFACE.

TYPICAL SECTION

COMPACTION DATA
EXISTING EMBANKMENT

MATERIAL TYPE	COMPACTIVE EFFORT ON 6 INCH LIFTS NO. OF PASSES	EQUIPMENT TYPE	AVG. DRY DENSITY (PCF)	AVG. MOISTURE (PERCENT)
U. S. PERVIOUS	4-6	DRUM ROLLER	130.1	9.3
RANDOM	8	SHEEPSFOOT ROLLER	124.5	10.9
CORE	8	SHEEPSFOOT ROLLER	118.6	12.9
D. S. PERVIOUS	4-6	DRUM ROLLER	127.4	9.8

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

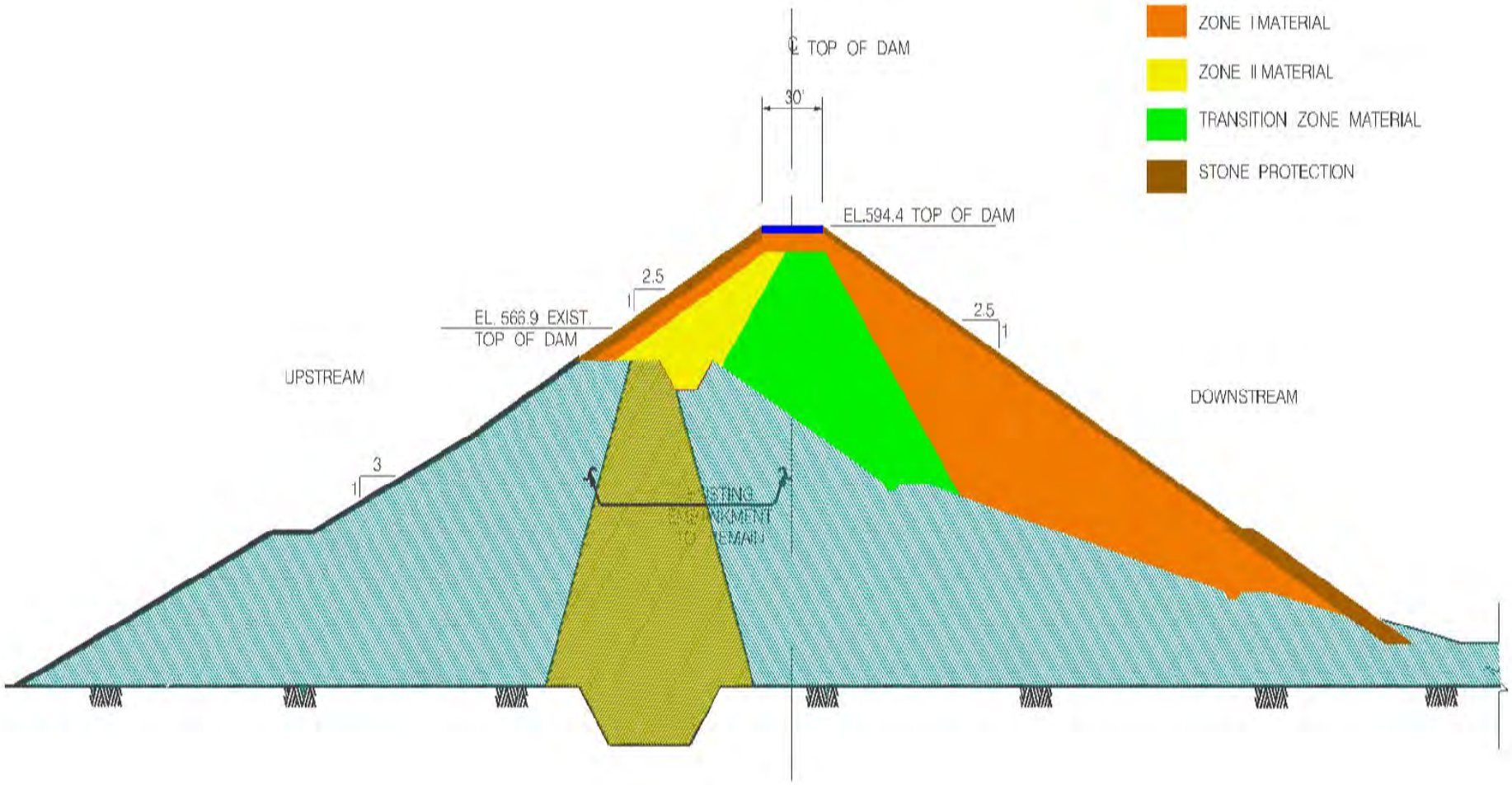
U.S. ARMY ENGINEER DISTRICT LOS ANGELES CORPS OF ENGINEERS

SANTA ANA RIVER BASIN, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PRADO DAM

TYPICAL EMBANKMENT SECTION

Typical Dam Section





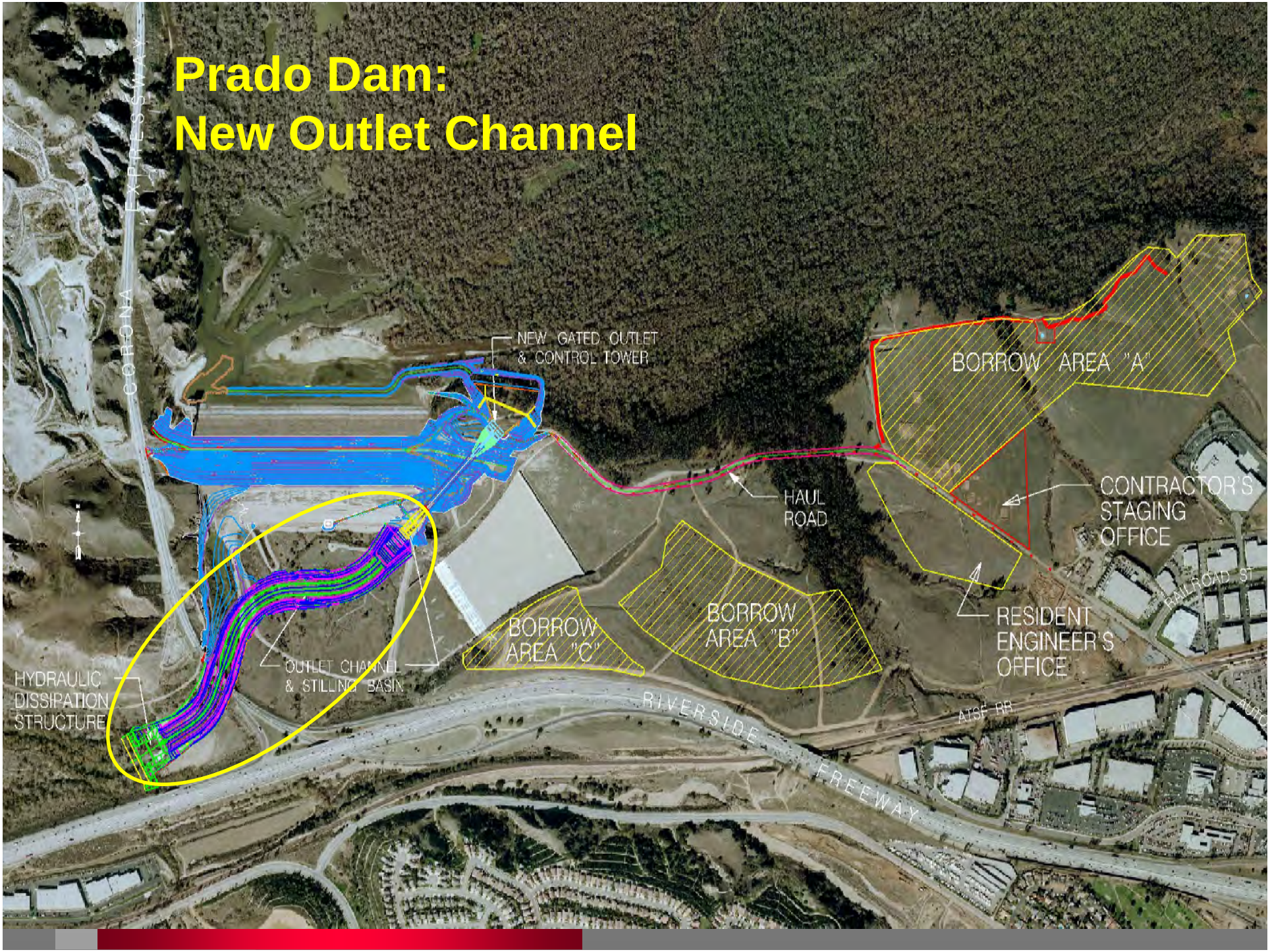

Zoned Embankment


2004 5 19

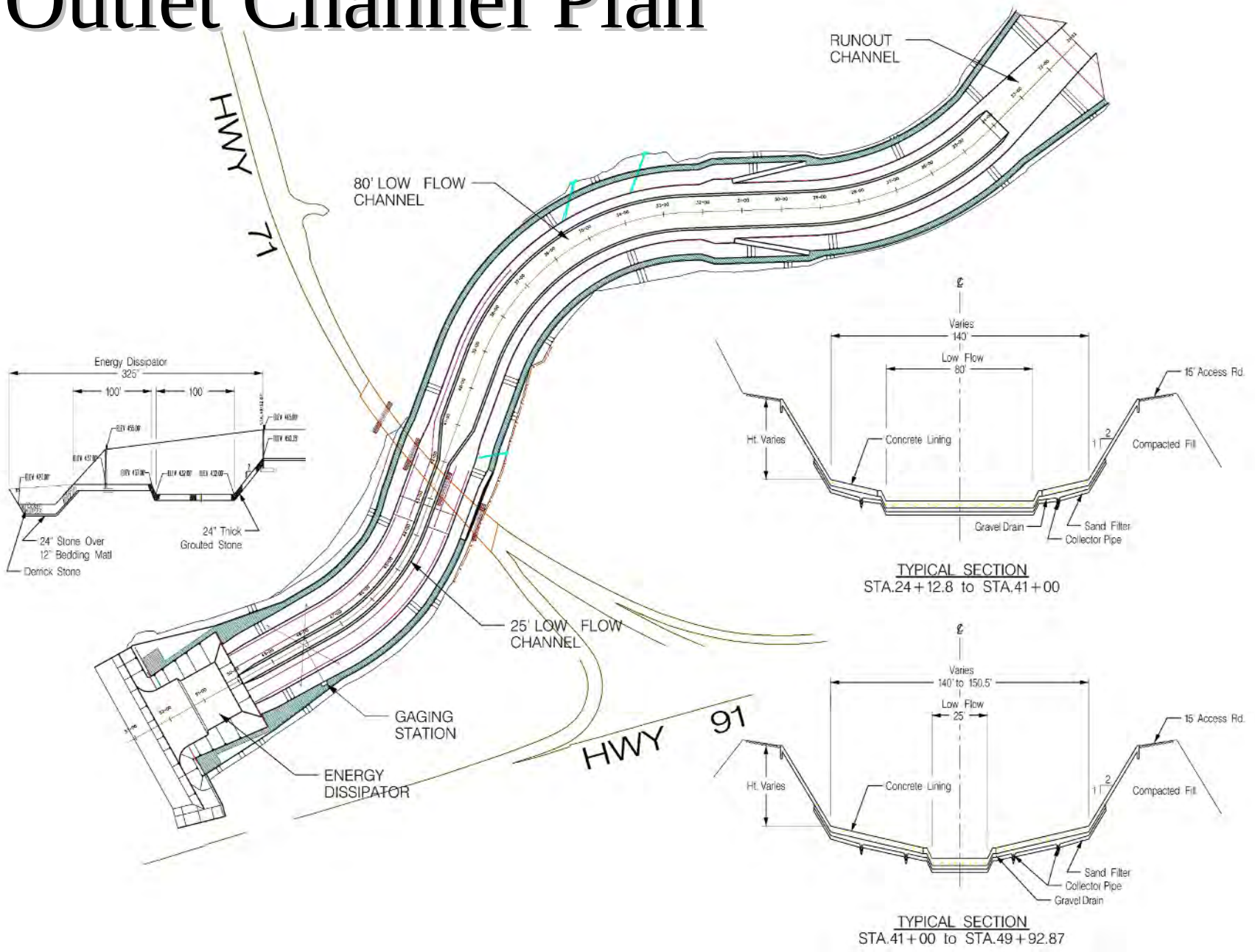

2004 5 24


2004 12 17

Prado Dam:
New Outlet Channel



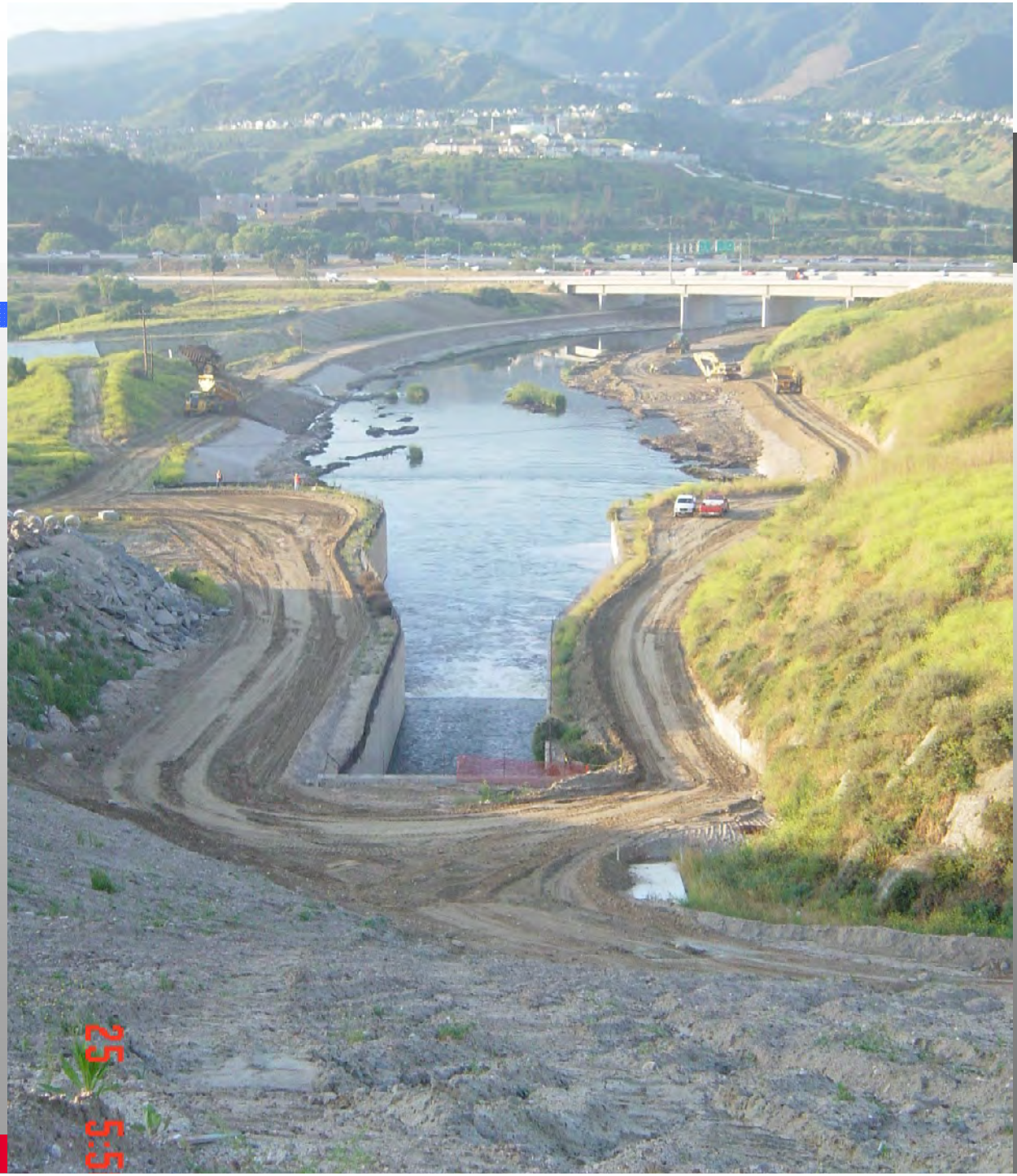
Outlet Channel Plan






2004 8 18


AUG 23 2004

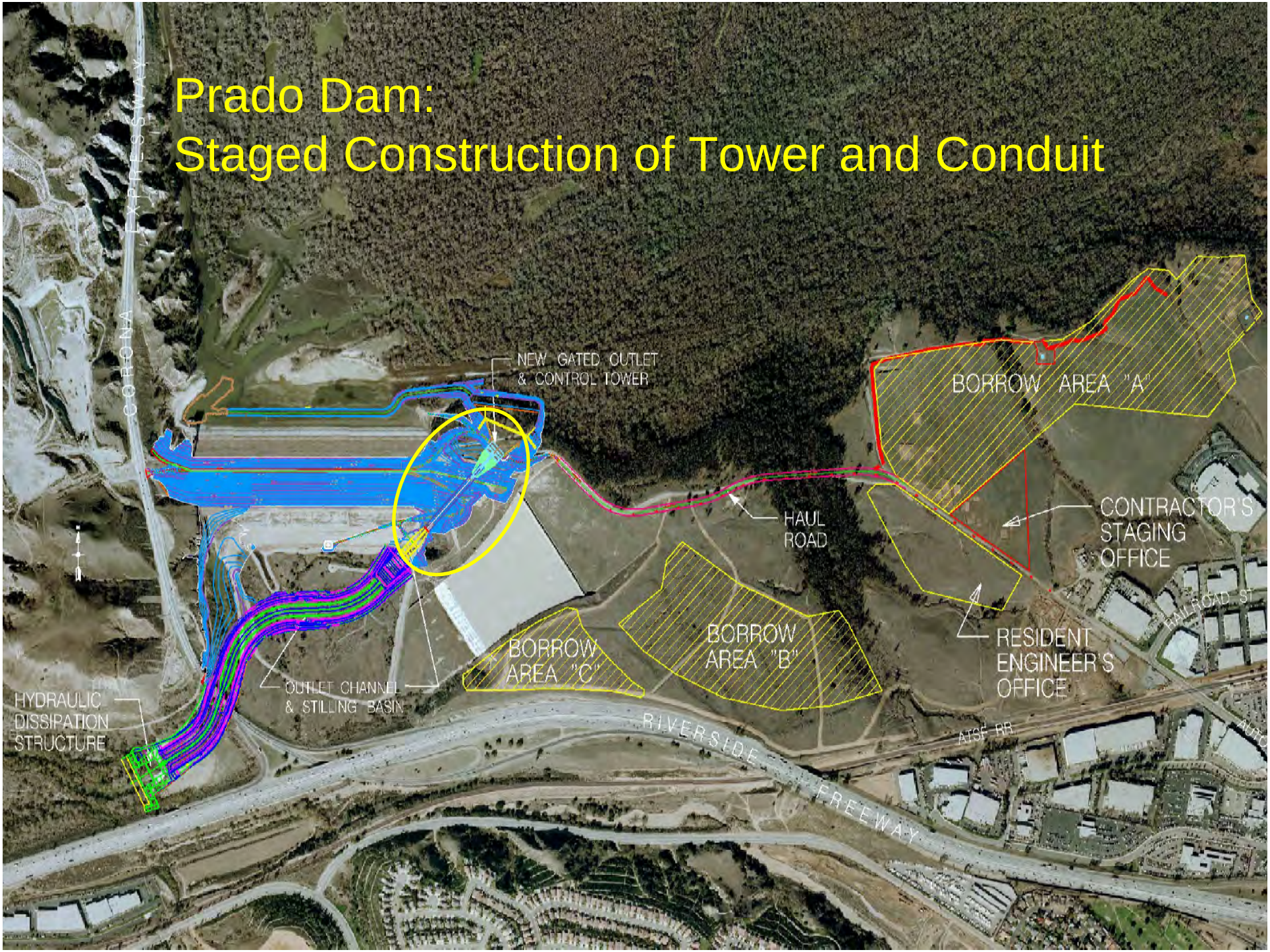


25
10:44 AM

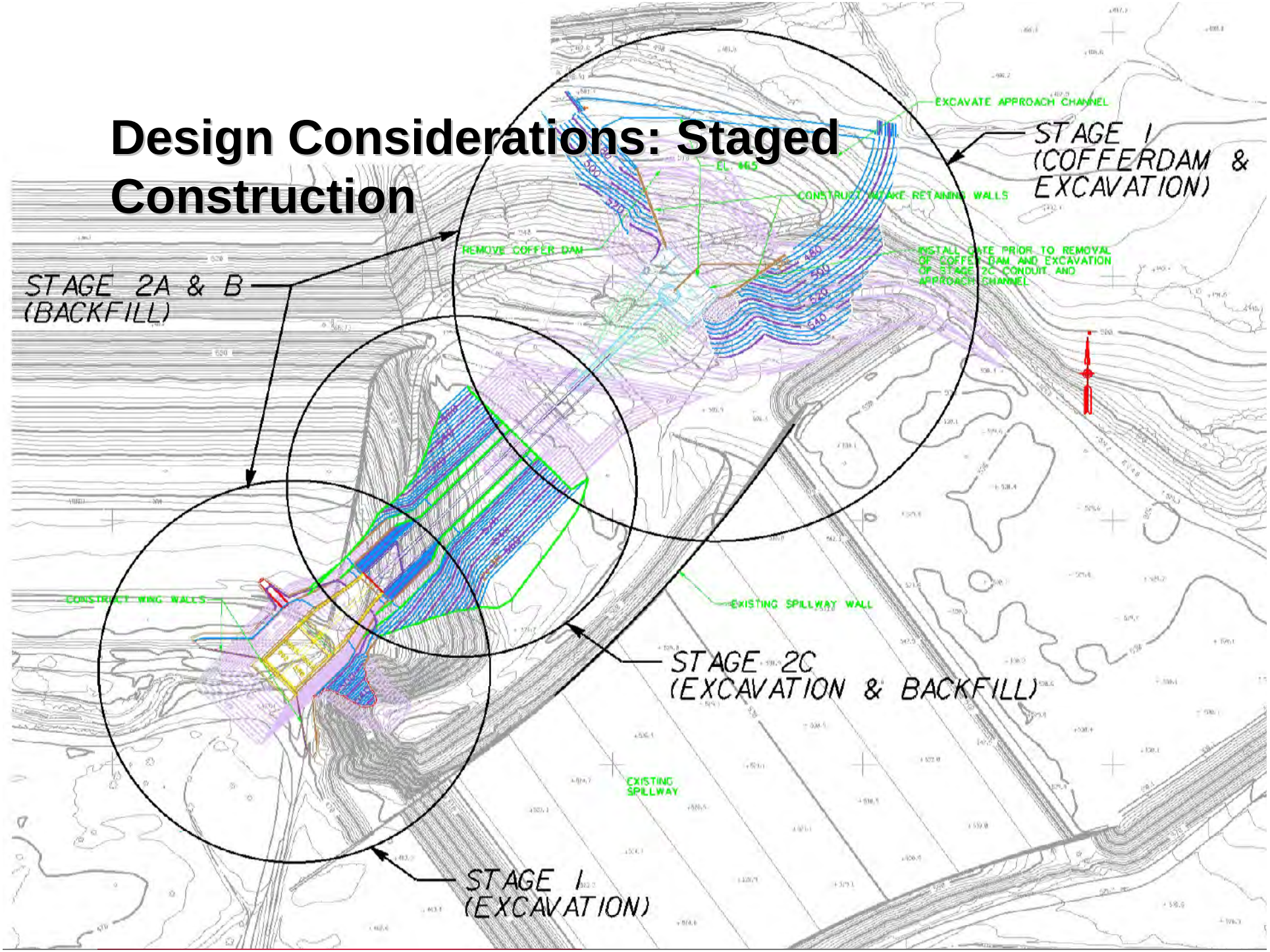

2005 4 28

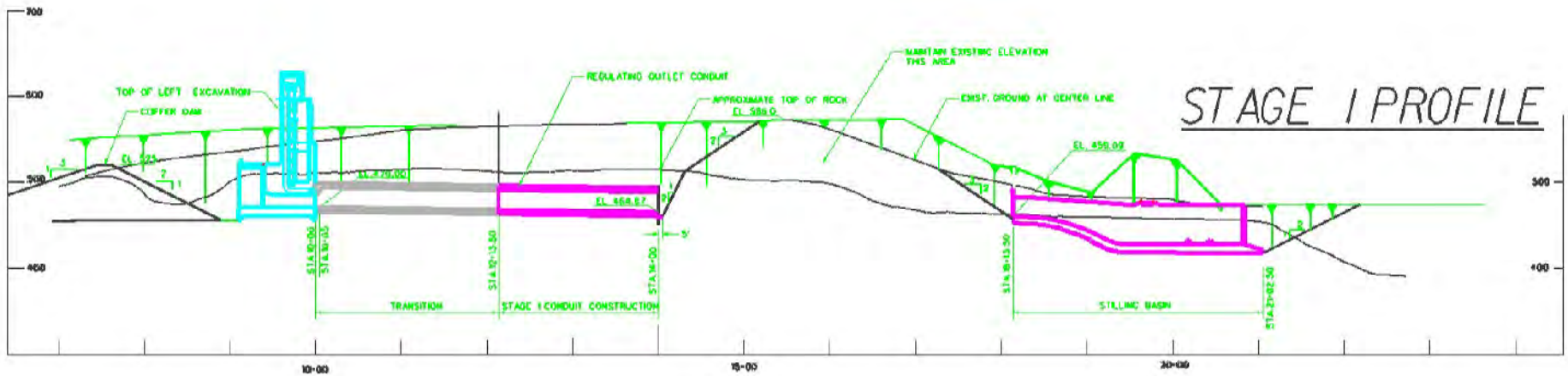


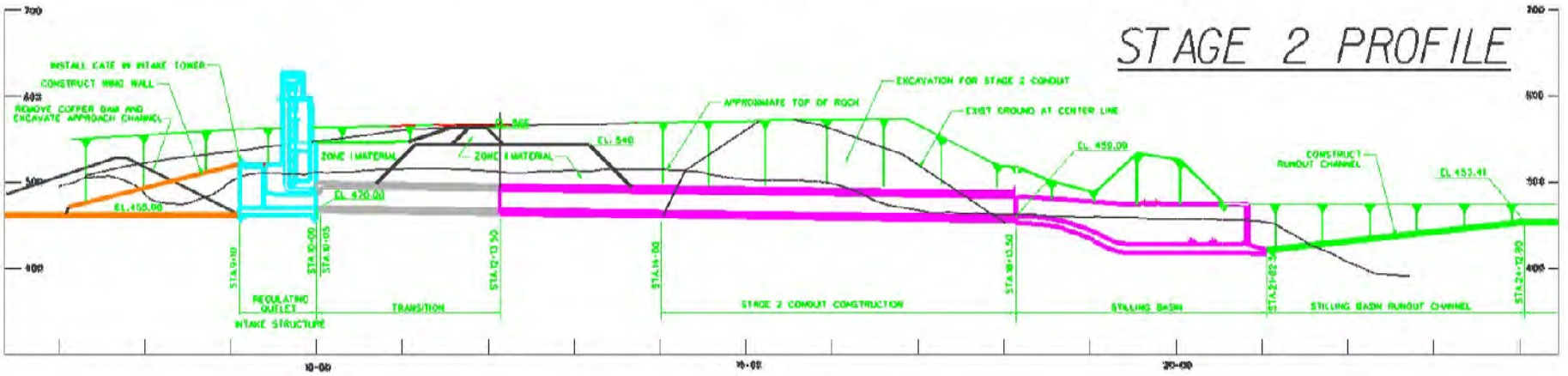
Prado Dam:
Staged Construction of Tower and Conduit

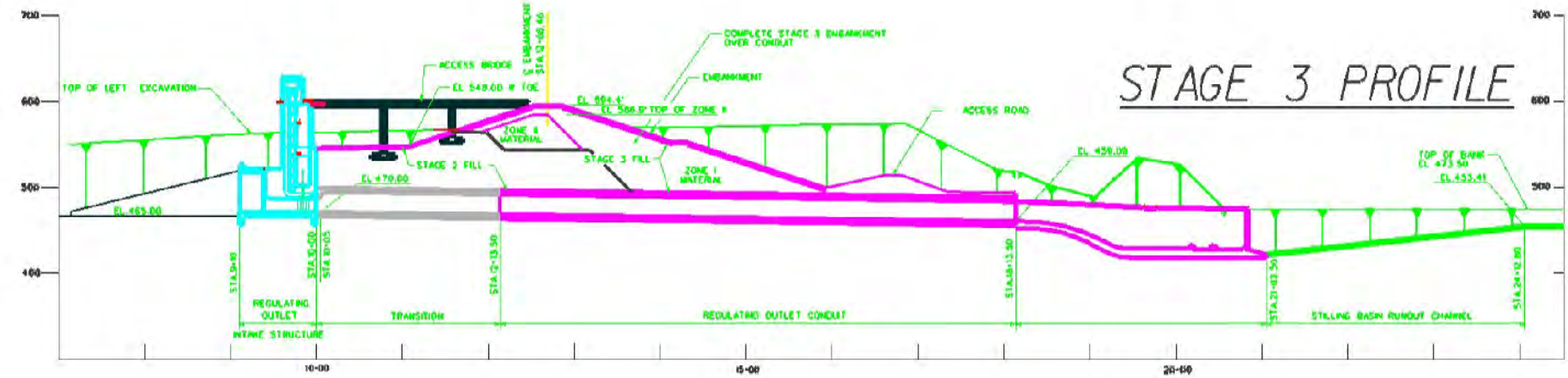


Design Considerations: Staged Construction

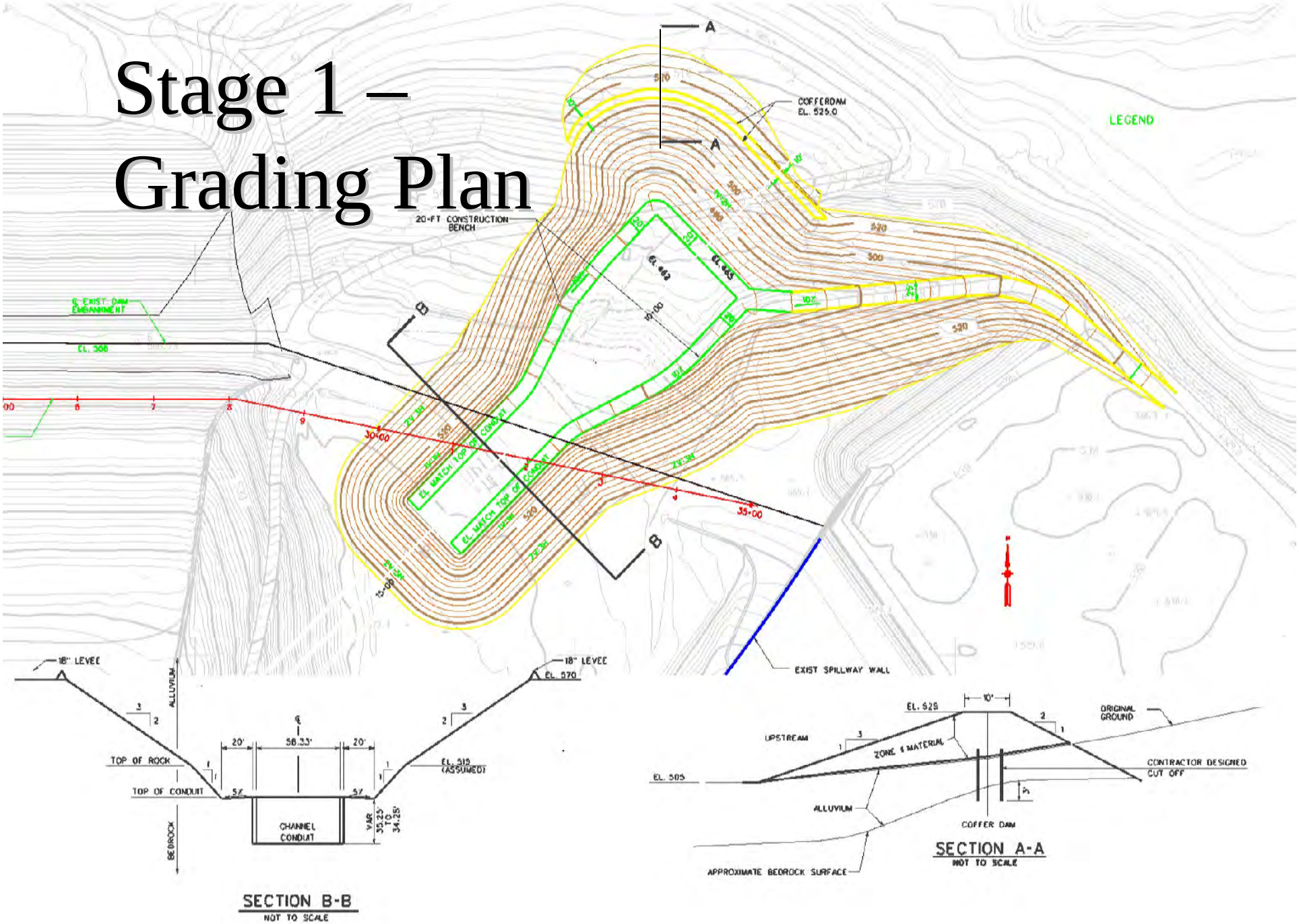



STAGE 1 PROFILE
TOP OF LEFT EXCAVATION
COFFER DAM
EL. 525
EL. 470.00
REGULATING OUTLET CONDUIT
APPROXIMATE TOP OF ROCK
EL. 589.0
MAINTAIN EXISTING ELEVATION THIS AREA
EXIST. GROUND AT CENTER LINE
EL. 459.02
EL. 464.67
TRANSITION
STAGE 1 CONDUIT CONSTRUCTION
STILLING BASIN


STAGE 2 PROFILE
INSTALL GATE IN INTAKE TOWER
CONSTRUCT WING WALL
REMOVE COFFER DAM AND EXCAVATE APPROACH CHANNEL
EL. 465.00
ZONE 1 MATERIAL
ZONE 1 MATERIAL
EL. 540
EL. 420.00
EXCAVATION FOR STAGE 2 CONDUIT
APPROXIMATE TOP OF ROCK
EXIST GROUND AT CENTER LINE
EL. 459.00
CONSTRUCT RUNOUT CHANNEL
EL. 453.41
REGULATING OUTLET INTAKE STRUCTURE
TRANSITION
STAGE 2 CONDUIT CONSTRUCTION
STILLING BASIN
STILLING BASIN RUNOUT CHANNEL


STAGE 3 PROFILE
TOP OF LEFT EXCAVATION
ACCESS BRIDGE
EL 548.00 @ TOE
EL. 465.00
EL 470.00
STAGE 2 FILL
ZONE 2 MATERIAL
STAGE 3 FILL
ZONE 1 MATERIAL
COMPLETE STAGE 3 EMBANKMENT OVER CONDUIT
EMBANKMENT
EL. 584.4'
EL. 586.5' TOP OF ZONE 2
ACCESS ROAD
EL. 459.00
TOP OF BANK EL 453.50
EL. 453.41
REGULATING OUTLET INTAKE STRUCTURE
TRANSITION
REGULATING OUTLET CONDUIT
STILLING BASIN RUNOUT CHANNEL

Stage 1 – Grading Plan



Stage 1 Excavation



Stage 1 Excavation



Cofferdam




Cofferdam 2
Cofferdam 1
2005 2 22


2003 8 5

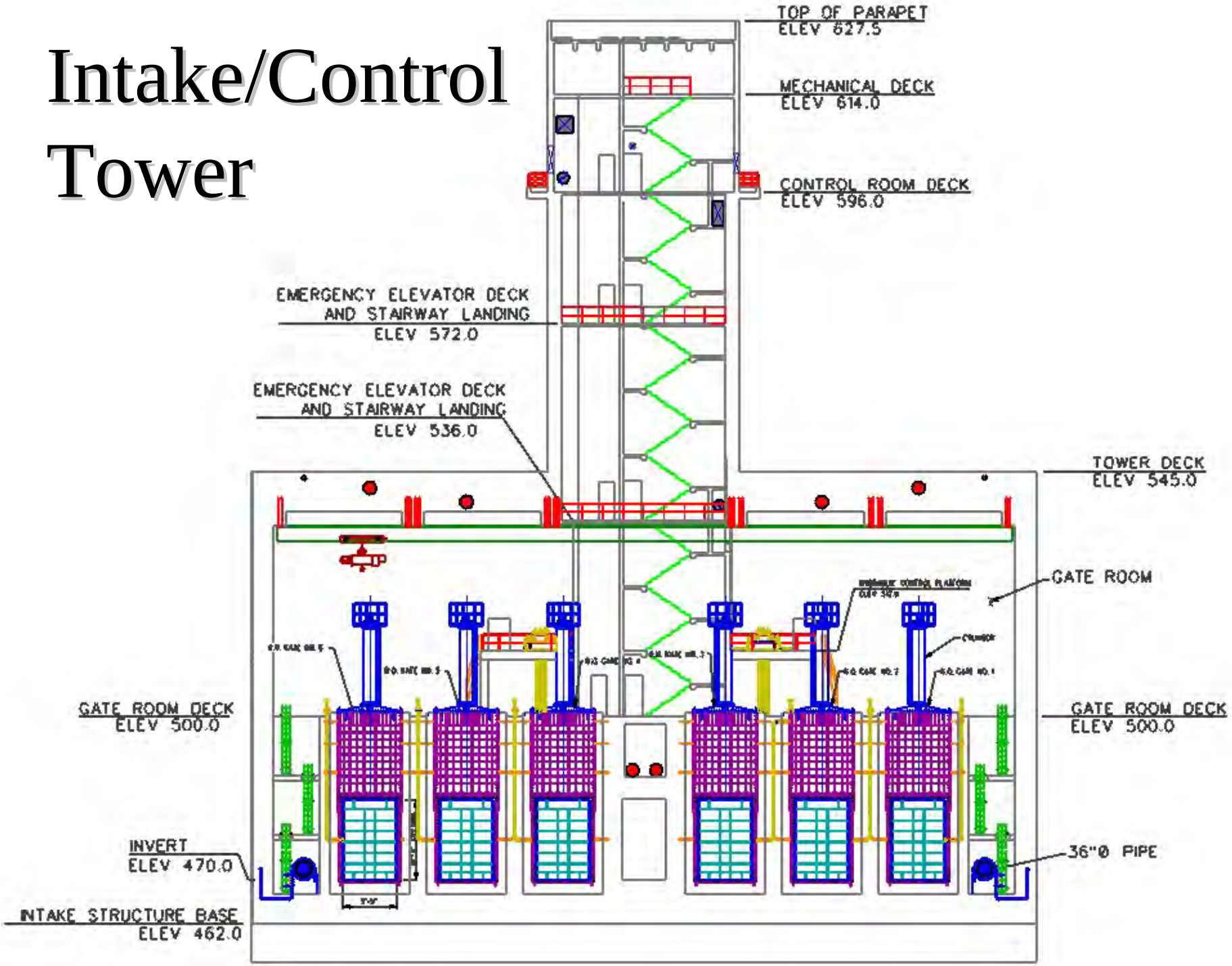

2003 8 11


YEAGER
CAT
2003 8 18

Cofferdam II – Miscellaneous Fill with Visqueen Liner



Intake/Control Tower




2004 10 1


DEC 10 2004


2004 7 29


2004 12 13



Received Thursday, 6 January 05

From the National Weather Service...

DISCUSSION:

.TODAY...NO PRECIP EXPECTED.

.FRIDAY...AND CONTINUING ALL THE WAY INTO TUESDAY OF NEXT WEEK...

AN EXTREMELY WET WEATHER PATTERN WILL IMPACT SOUTHERN CALIFORNIA.

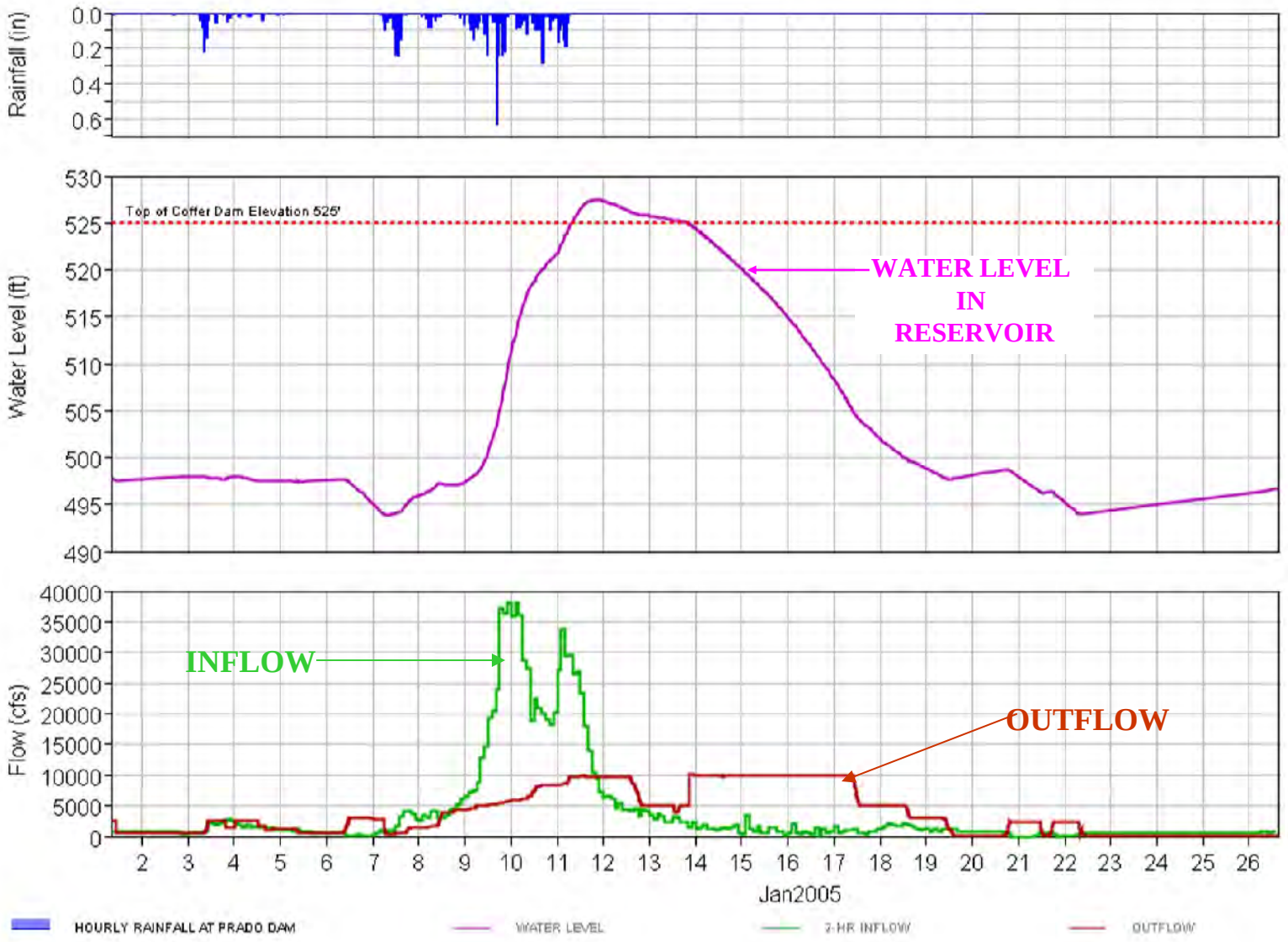
A TROPICAL PLUME KNOWN AS THE PINEAPPLE EXPRESS WILL BE FEEDING

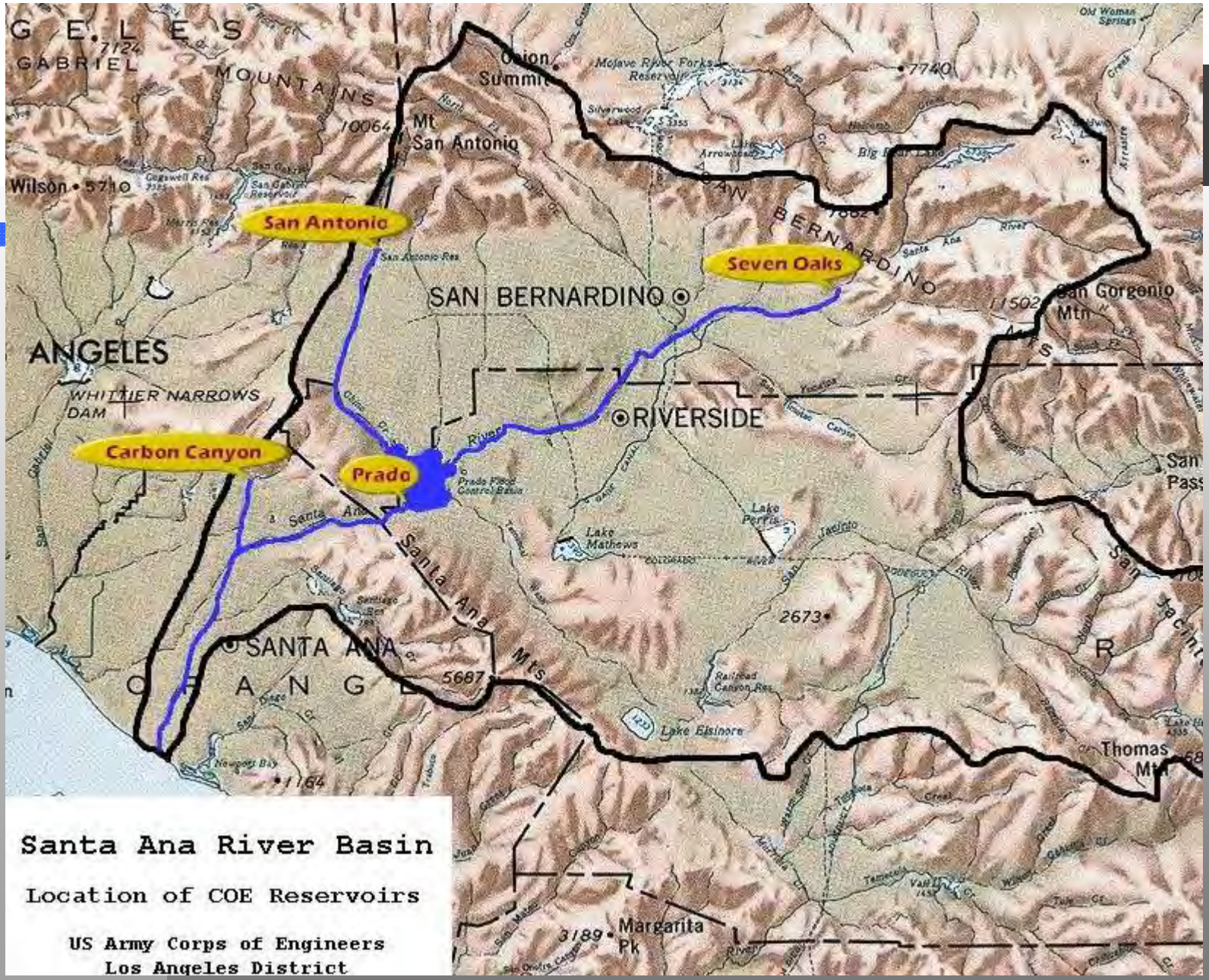
MOISTURE INTO A SERIES OF PACIFIC STORMS. HEAVY RAINS WILL CAUSE

URBAN FLOODING AND MOUNTAIN MUDSLIDES. SOME RIVERS WILL BE SUSCEPTIBLE TO OVERFLOW. **THIS WEATHER PATTERN LOOKS SIMILAR TO THE ONE THAT PRODUCED THE FLOODS IN THE YEAR 1969.** 50KT WARM MOIST SW WINDS FROM 5000 TO 10000 FEET ENSURES THAT ALL SOUTH AND WEST FACING MOUNTAIN SLOPES WILL GET HUGE STORM TOTALS FOR THE 5 DAY PERIOD ENDING TUESDAY.

Prado Dam Operation

Jan 1-25, 2005




San Antonio
Seven Oaks
Carbon Canyon
Prado
SAN BERNARDINO
RIVERSIDE
ANGELES
WHITTIER NARROWS DAM
SANTA ANA
Santa Ana Mts
Lake Elsinore
Lake Mathews
Lake Perris
Mt San Antonio
San Gorgonio Mtn
Thomas Mt
Margarita Pk
Santa Ana River Basin
Location of COE Reservoirs
US Army Corps of Engineers
Los Angeles District


JAN 10 2005


JAN 11 2005


JAN 11 2005


2005 1 11


JAN 11 2005

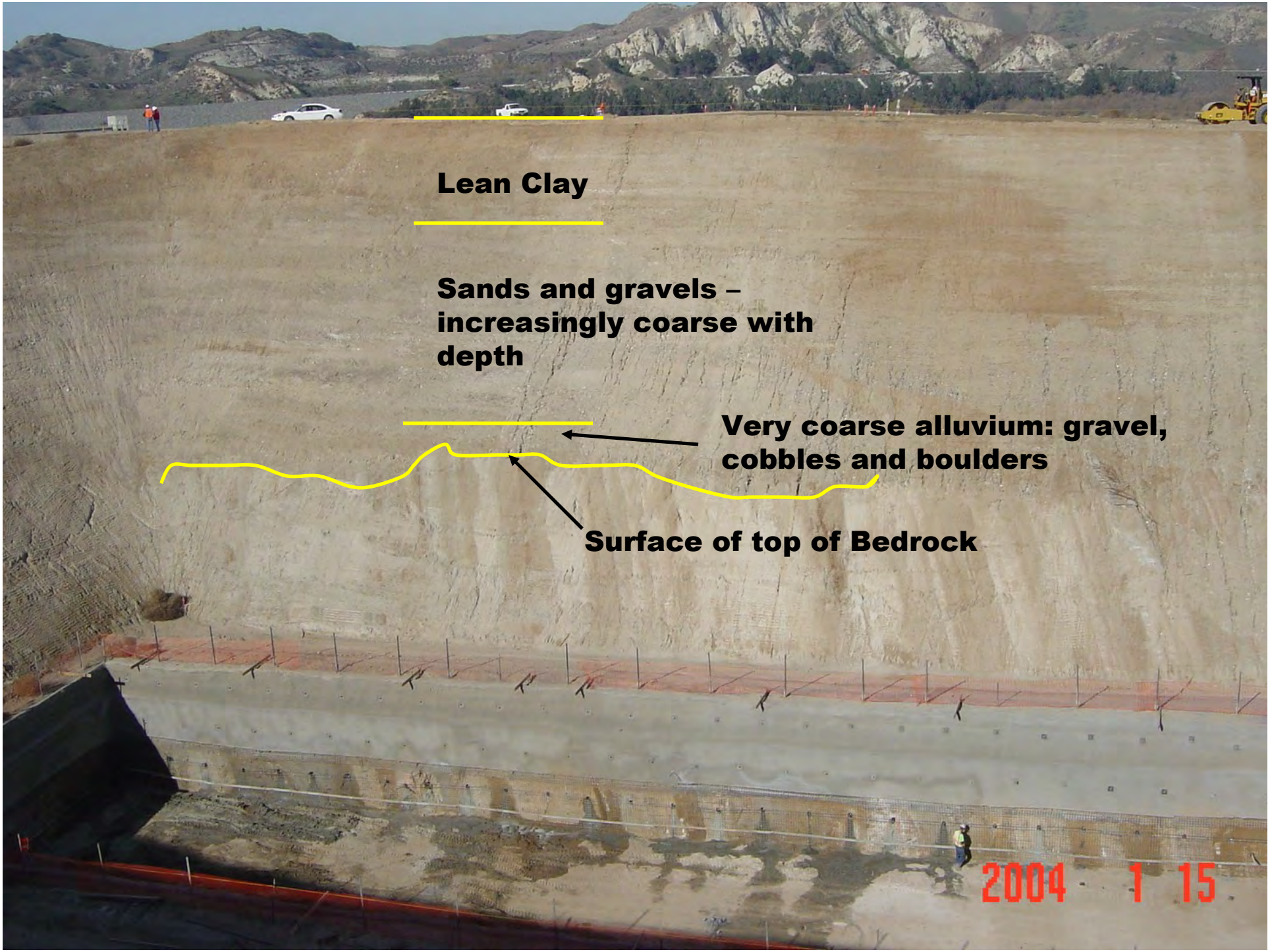

2005 1 11


2005 5 23

2005 1 12






Lean Clay
Sands and gravels – increasingly coarse with depth
Very coarse alluvium: gravel, cobbles and boulders
Surface of top of Bedrock
2004 1 15

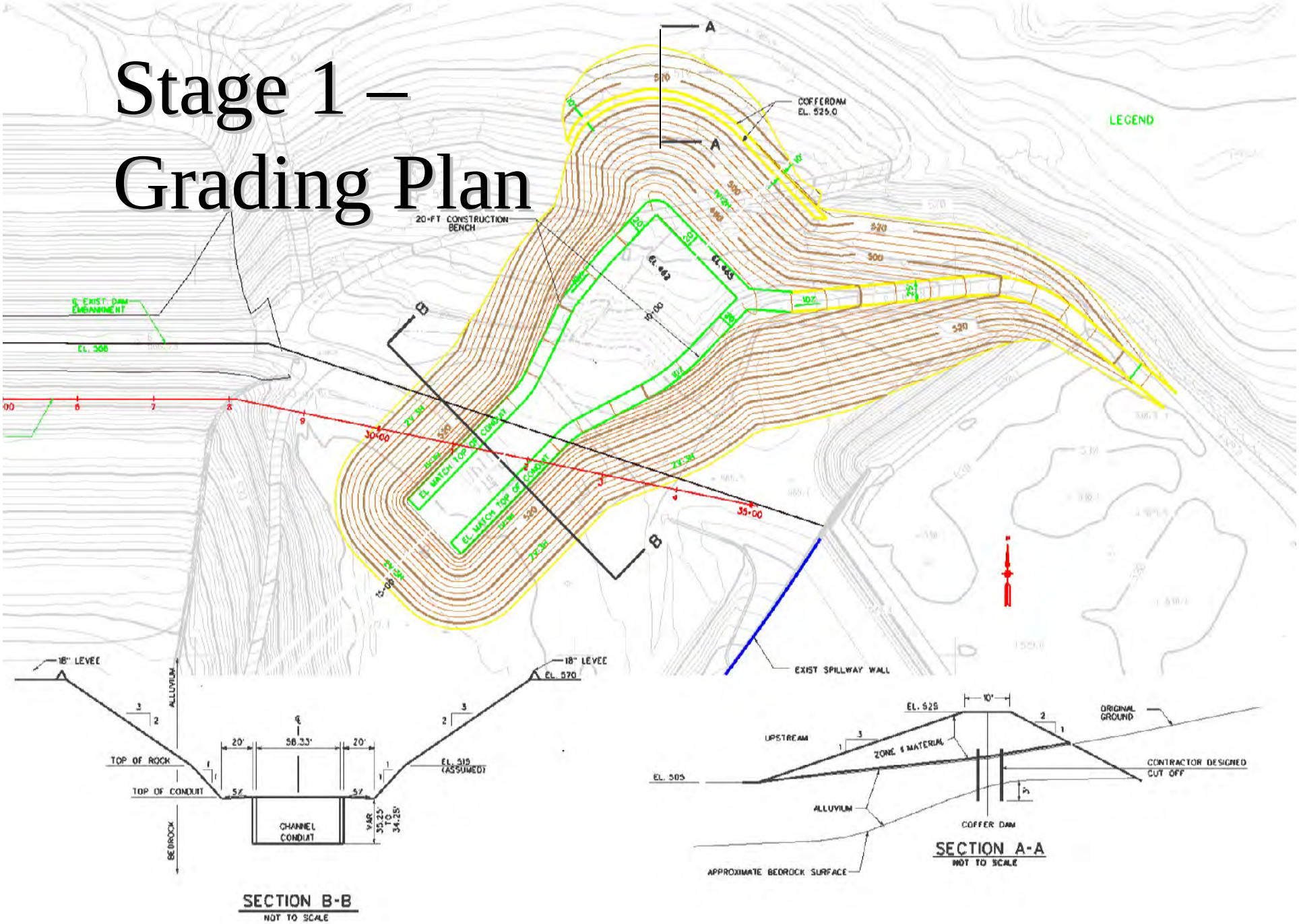

2005 1 19


2005 1 19

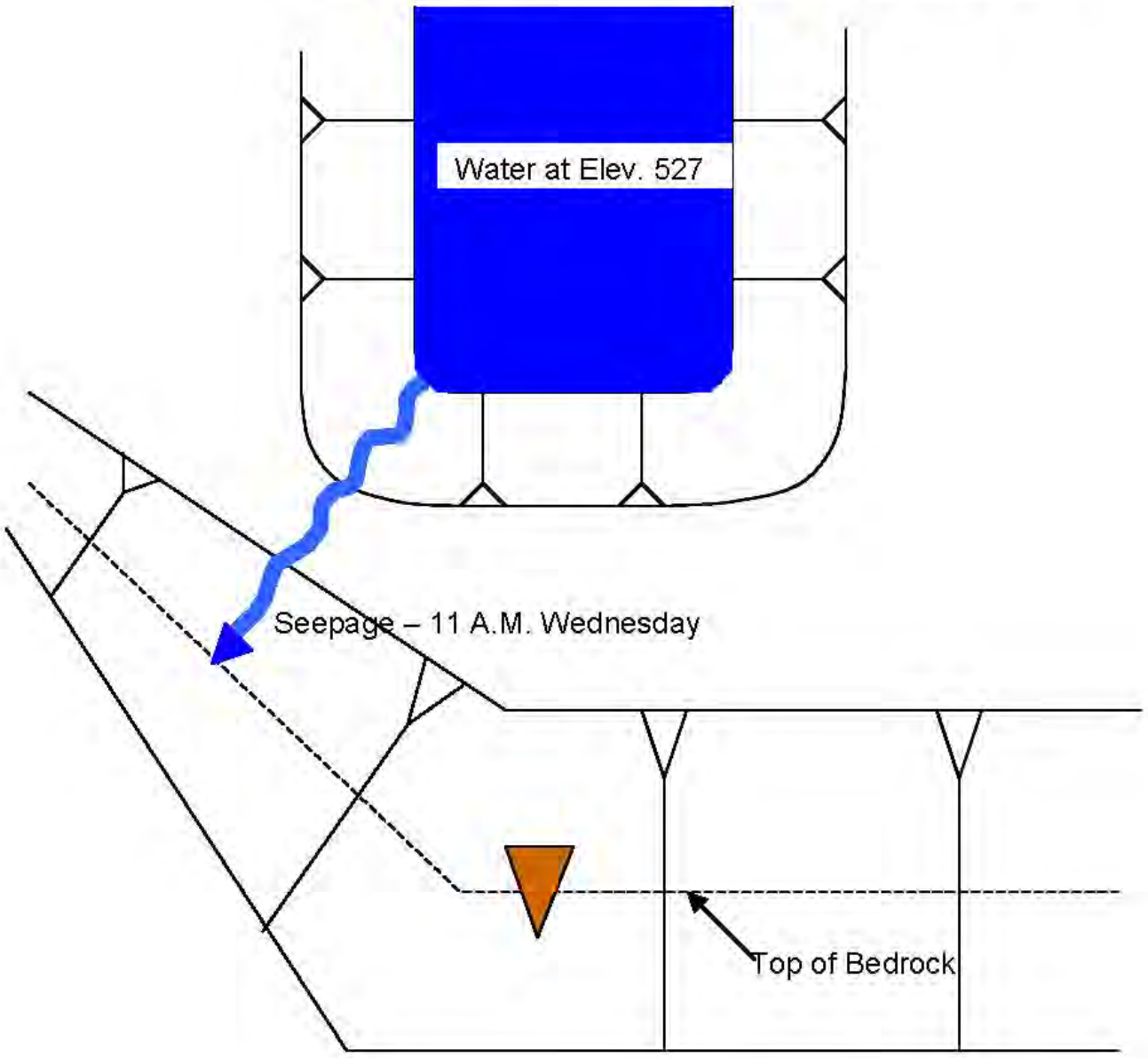
A stability analysis was conducted by the Los Angeles District Geotechnical Group on the "Thin Section" in December 2003. Among other things, the reported concluded:

"Catastrophic failure due to seepage will not occur as gradient would be much less than critical"

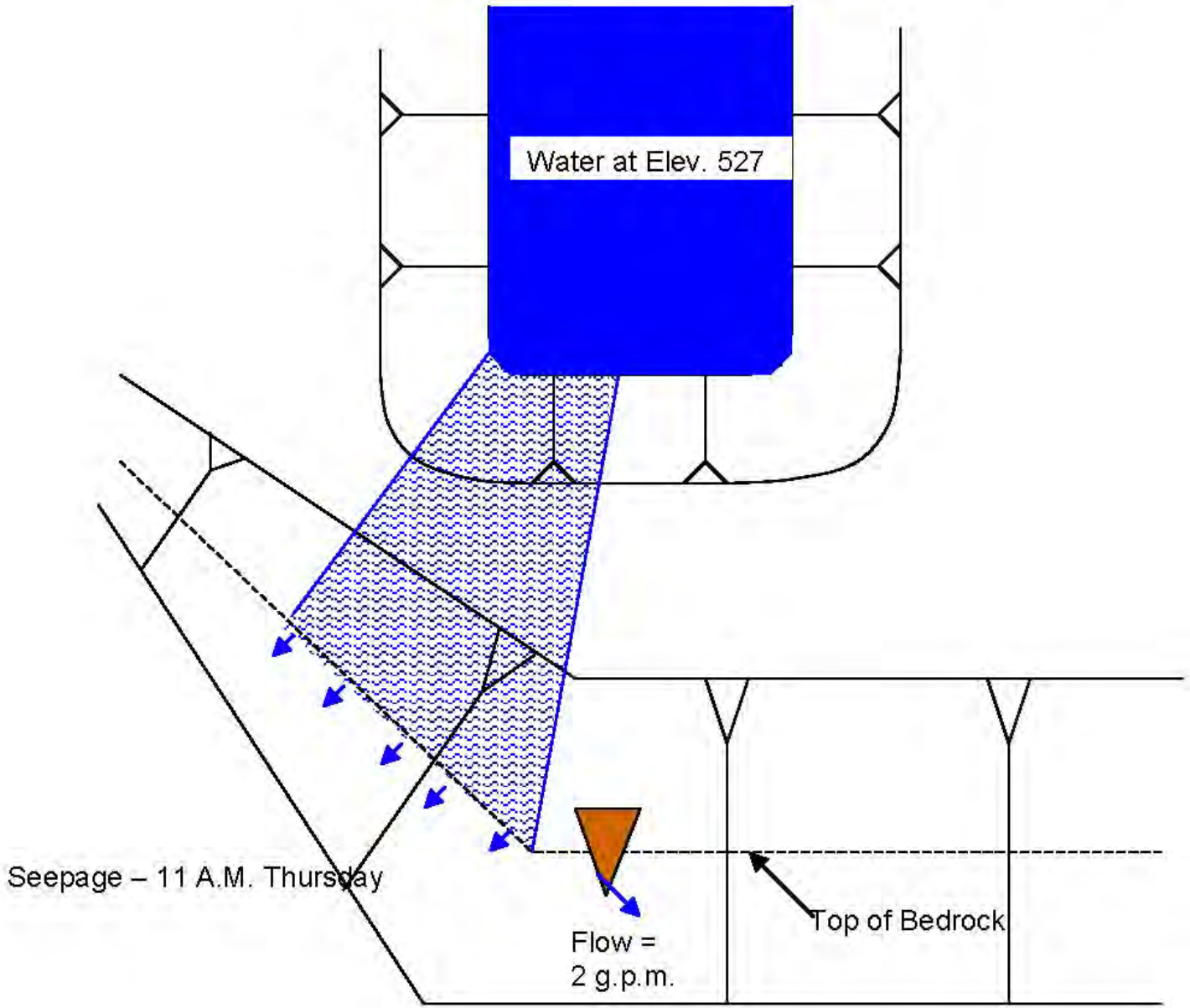
Stage 1 – Grading Plan



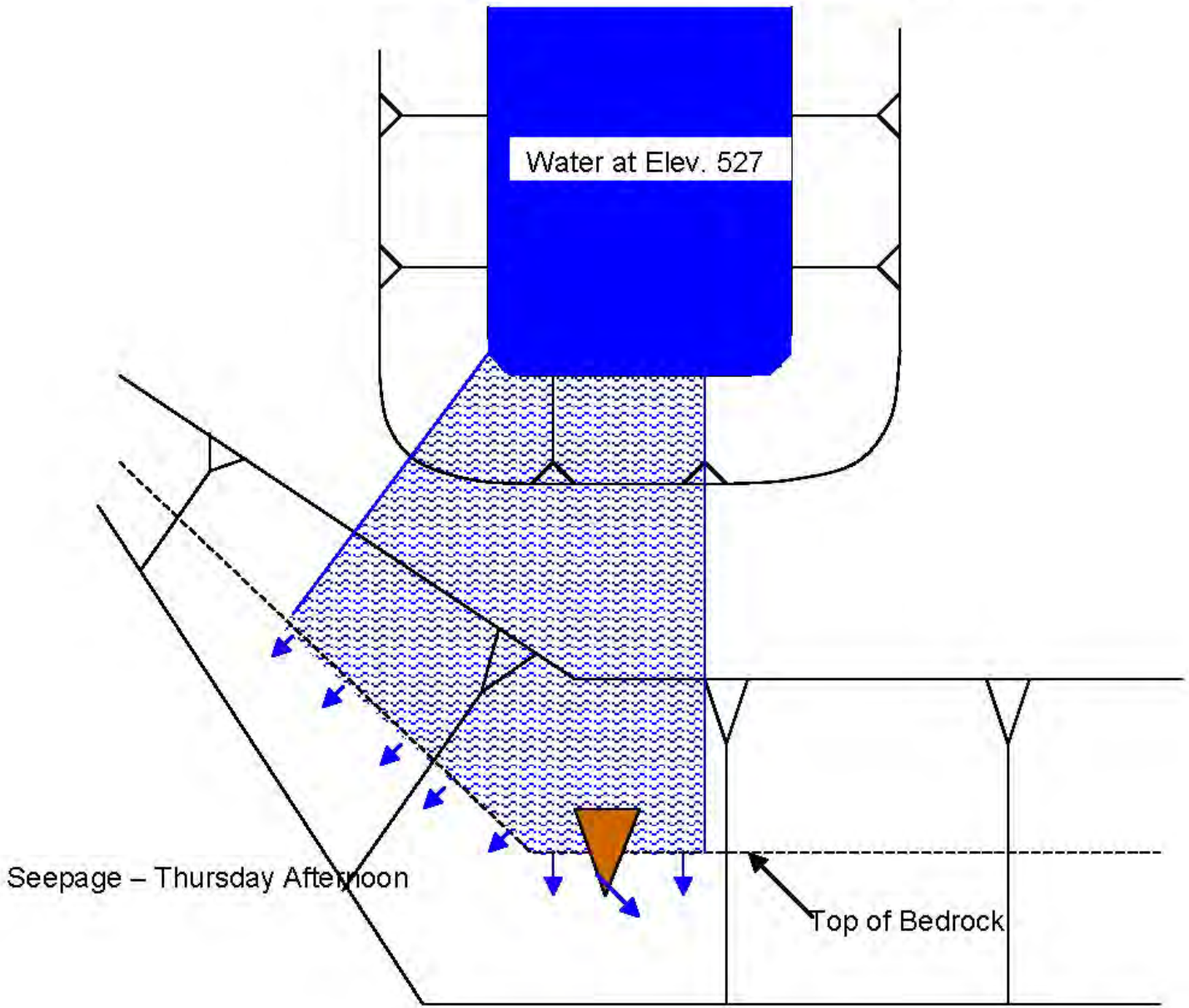
Simplified Plan View – Left Abutment



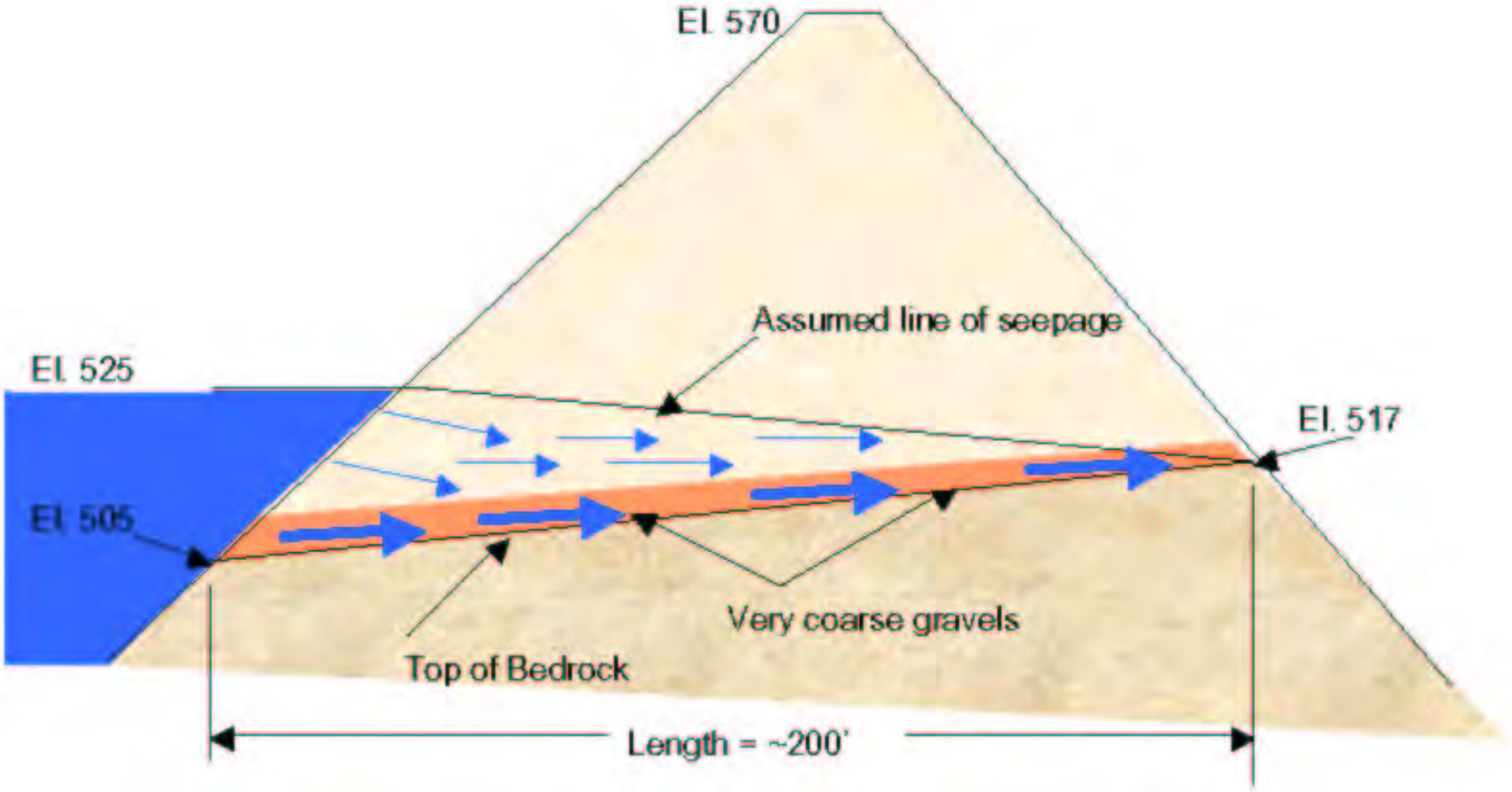
Simplified Plan View – Left Abutment



Simplified Plan View – Left Abutment



Cross-Section through Thinnest Section of Left Abutment




2004 8 1


• 2 gpm of seepage
• Water cloudy, but not muddy
• Flow rate, clarity constant
2005 1 14

LA District's Opinion on the Seepage

- Predictable, given the site geology
- Quantity of seepage increased as the saturation front developed
- Low head, low exit gradient
- No cause for concern, but "V-Trench" must be monitored



Small leak, big response

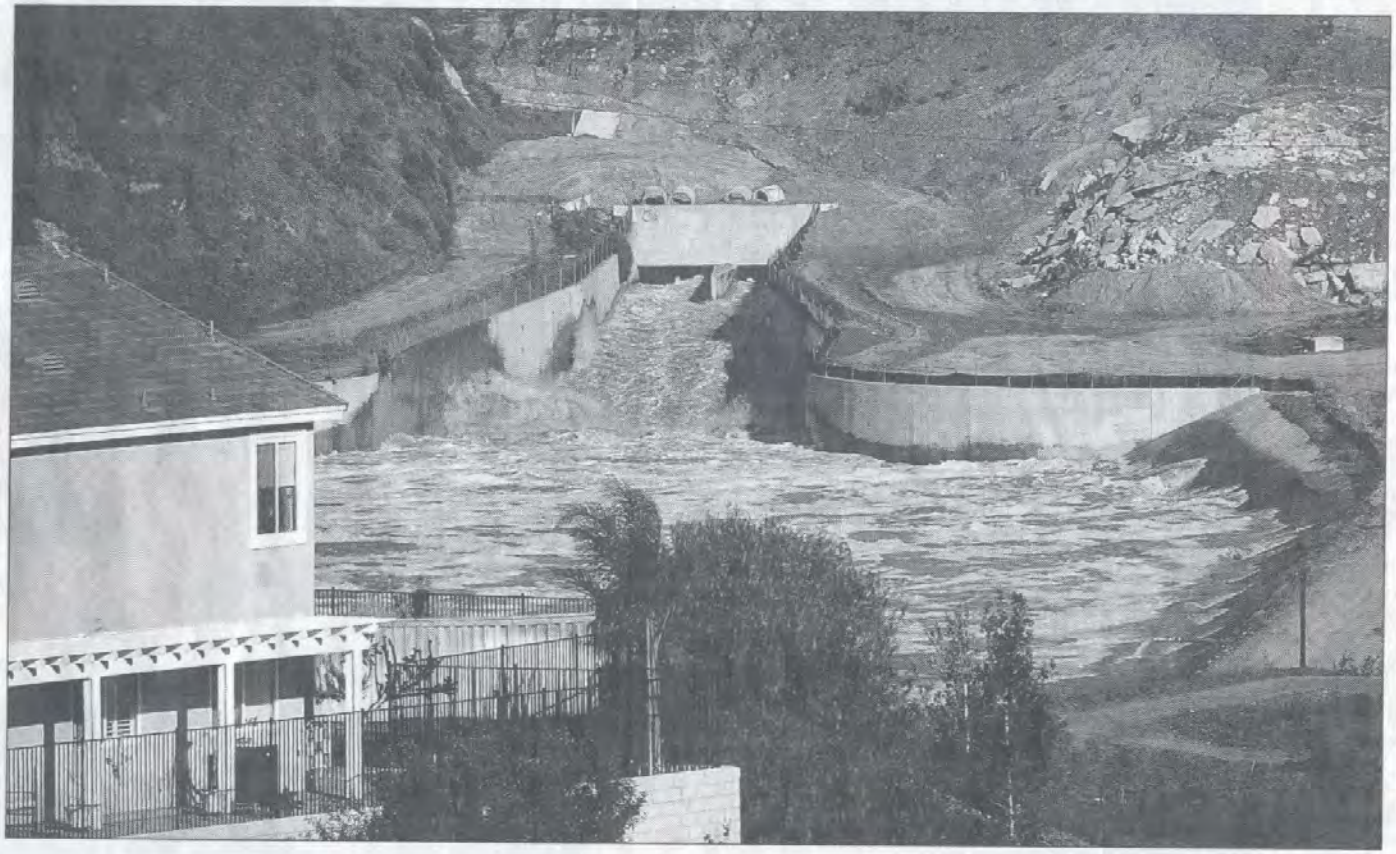
Easy repair needed when water seeps from Prado Dam after recent deluge, prompting Corona, O.C. evacuations.

By PAT BRENNAN
and AMANDA BECK
THE ORANGE COUNTY REGISTER

A leak at Prado Dam on Friday that initially worried city and county officials, prompting evacuations, turned out to be small and relatively easy to repair. But it served as a powerful reminder of the enormous force of the water that fell on Southern California during more than four days of rain that rapidly filled the basin behind the dam, just northeast of Orange County.

Q: What caused the leak?
A: Construction crews with a contracting firm, Yeager-Skanska Inc. in Riverside County, are raising the dam by 28 feet to provide increased flood protection for Orange County.

They are also installing a



OVERFLO
An outlet
Prado Dan
releases w
at high ca
ity Friday,
when a lea
at the dam
caused eva
uations of
more than
2,000 in
nearby hor
The leak, i
face of the
dam, devel
oped after
heavy flow
from the r
cent storm
filled a pit
is normally
placing pre
sure on the
dam.

BRUCE
CHAMBERS,
THE REGISTE

cials. Early Friday morning, Army Corps engineers thought there could be a small chance that the leak

Prado Dam springs a small leak

A small leak in Prado Dam prompted evacuations of more than 2,000 people Friday. The leak, in the

Floods and flood control

1,000 people evacuated by Corona dam

State: Seepage threatened to flood area; release eases pressure.

By Ryan Pearson
Associated Press



CORONA — Authorities released a fierce, brown river of water from a Riverside County dam and evacuated more than 1,000 people from its path Friday after a temporary earthen barrier at the site began seeping water.

The U.S. Army Corps of Engineers unleashed more than 10,000 cubic feet of water per second to relieve pressure on the earthen dam 50 miles east-southeast of Los Angeles after more water than usual began pushing through the dirt of a temporary coffer dam that is protecting workers who are extending and raising the dam.

"That's like a swimming pool every second," Corona Mayor Darrell Talbert said.

The water gushed into the Santa Ana River, whose banks were deep enough to handle the flow without flooding, said Lt. Col. John Guenther, deputy commander of the

...photographs the swollen Santa Ana River from the entrance bridge to Green River Golf Club Saturday morning.

Residents leery over returning

CONTINUED FROM A1

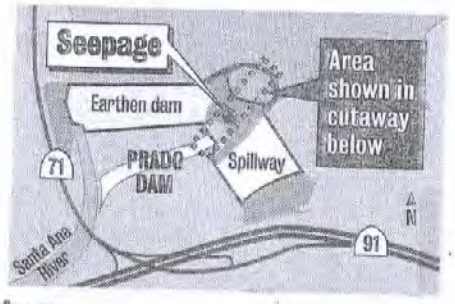
Officials with the Army Corps of Engineers, which had been raising the dam to increase flood protection, said they were satisfied with the repair job, adding that the seepage of as much as 10 gallons a minute was minor and didn't threaten the dam's safety.

"The pressure behind the dam was the most ever, more than it's had since it's been built," spokesman Fred-Otto Egeler said. "We had to release pressure from the dam but there was no imminent danger. It wasn't us who declared it a disaster."

The seepage developed Thursday night after weeks of heavy rain raised the water above a temporary barrier called a cofferdam that was designed to protect workers and the construction project.

Water spilled over the cofferdam and put pressure on a naturally occurring embankment of bedrock, gravel and soil alongside the dam. Earthmovers had carved into the embank-

STOPPING A LEAK: Seepage was discovered Thursday on the downstream face of Prado Dam where construction was being done on the new intake gate and outlet works. The Army Corps of Engineers took immediate steps to correct and repair the problem.

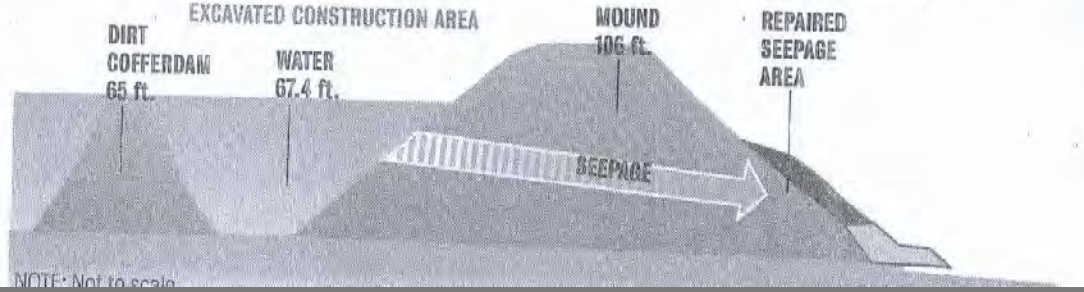


The problem:

- The temporary dirt cofferdam was built 65 feet high to keep water out of an area excavated for construction.
- Recent heavy rains caused Prado Reservoir to rise to 67.4 feet, which flooded the area.
- Water seeped through the hill that is part of the earthen dam.

The solution:

- Water being released from the dam has been increased from 5,000 to 10,000 cubic feet per second to drop the reservoir level and relieve pressure on the dam.
- The face of the dam where seepage has been found is being shored up with additional dirt.
- The seepage area is being reinforced with a fine mesh called geotextile to keep it stabilized.



but it's good to be informed," Trifunac said. "I don't want to scare you or leave the wrong impression, but dams are complex structures and it takes a lot of looking at details to know what is going on."

If he lived downstream from the Prado Dam, Trifunac said, "I would invite some very knowledgeable people who design dams to give a talk."

The Prado Dam was built in 1941 to protect then-agricultural Orange County from repeated floods, and that protection enabled the later suburbanization of that region.

David Moreno recalled his father's escape in the late 1930s from a flood that killed a thousand head of cattle and forced his family from the rural town of Prado.

"He had to run for his life," said Moreno, 54, of Norco. "From the time they could get out of the house and climb to where Highway 71 is, it flooded that quick."

The Army Corps of Engineers

VOL 10 NO 21 JANUARY 28-FEBRUARY 3 2005 ~ OCWEEKLY.COM ~ SERVING

BATTLE OF THE BOONDOGGLES (LIGHT-RAIL DIVISION) • **DON'T BLAME GOD** IF PRADO DAM BREAKS
NU-METAL GODS HELMET • **THE MAN WHO LOVED TWO BRAINS**: SONTAG AND KAEL

OCWEEKLY

FREE



NECKFACE'S DEVIL,

THOMAS CAMPBELL'S ABSTRACTS

AND ED TEMPLETON'S

SAD LITTLE MONSTERS

HELP MAKE

Events of Thursday Evening, 13 January 2005

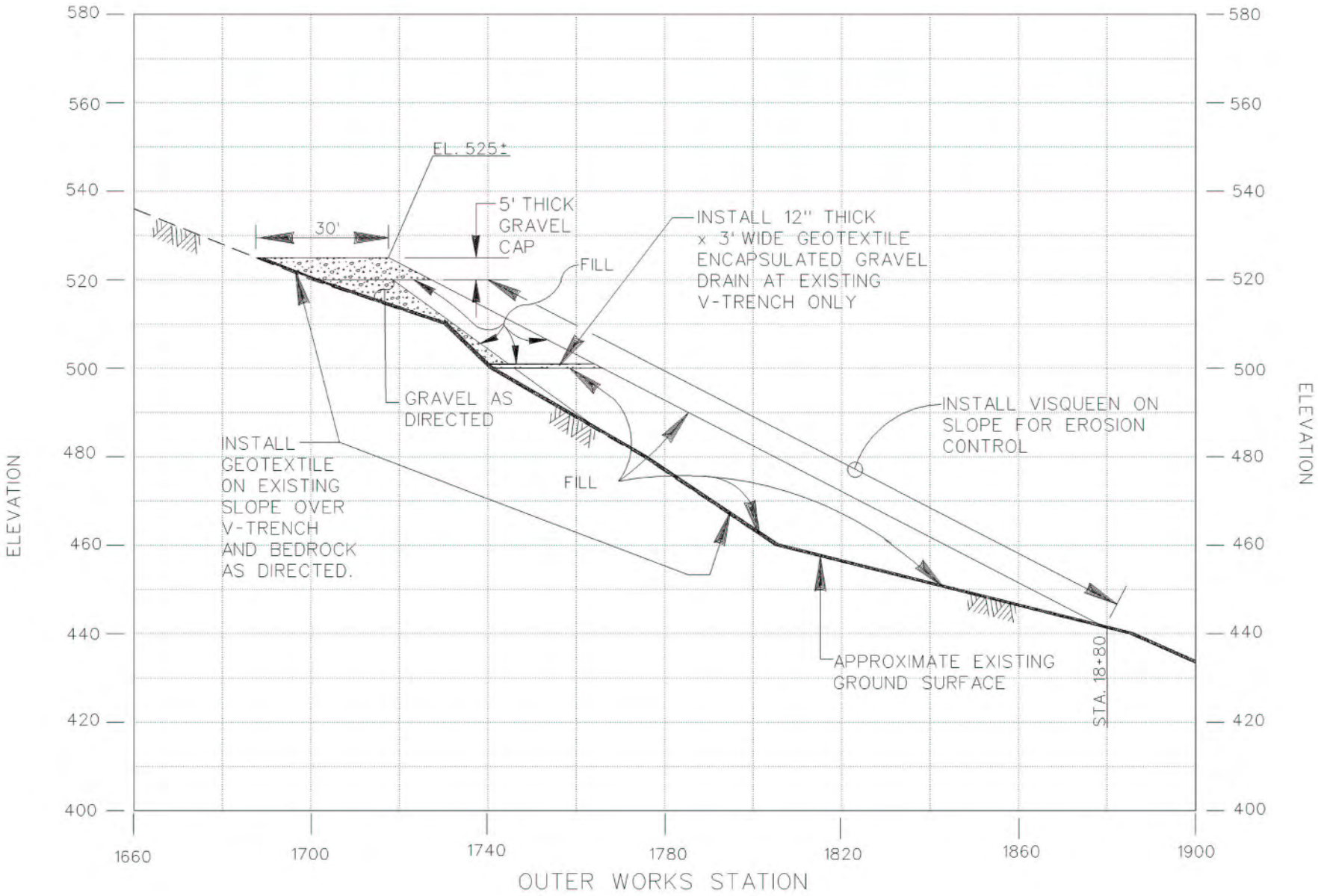
- **1500 hrs.** I inspect area and note the seepage area had expanded (approx 200 sq ft) but no velocity increase. Rate approximately 20 gpm. No piping of fines were observed. Approximately 2 gpm still out of V-trench. I met with YSI CQC and earthwork foreman to discuss potential actions should situation deteriorate. Briefed RE that I did not see a problem at this time.
- **1700 hrs.** I leave site for the evening.
- **1730 hrs.** At request of YSI CQC representative, their geotechnical consultant arrives to inspect site. He did not share my confidence.
- **1930 hrs.** Corps Dam Expert, after speaking with Contractor's consultant, understands that seepage was now "15 times greater than 24 hours ago, that it contained fines, that headward erosion and sloughing were observed along the gravel and cobble layer and that the consultant believes a stability berm is needed immediately."
- **1930 hrs.** Speaking to RE, Corps Dam Expert concurs with consultants recommendation to mobilize the contractor's equipment to begin construction of the stability berm and increase discharge to 10,000 cfs.

Events of Thursday Evening, 13 January 2005

- **2022 hrs.** Reservoir Operations begin to ramp up releases.
- **2100 hrs.** I returned and found no significant change in seepage. Request my supervisor and Byron Rathbun (7 Oaks Dam embankment engineer) to come to the site and provide additional opinions.
- **2200 hrs.** Mr. Rathbun and Mr. James Farley, Chief of Soils Design and Materials Section, arrived and inspected the site. Both concurred that the seepage did not merit mitigating measures at that time.
- **2200 hrs.** Contractor requests California Highway Patrol assist with traffic control when they arrived at the dam. Corona PD hear CHP radio traffic about closing Hwy 71 to get additional construction equipment to Prado and informed the Corona Fire Department.
- **2300 hrs.** District Commander directs RE to begin construction of the buttress for preventative measures.

So why did Prado make the news?

1. Extremely large event – record 5-day inflow
2. Inaccurate information
   - Seepage volume increased, not seepage velocity
3. Incorrect assessment
   - GE believed seepage to be carrying fines.
   - Mistook a small localized slump for headward erosion
   - He did stability not seepage/piping analysis.
4. Unnecessary recommendation – lead to emergency mobilization
5. Poor communications with locals



BUTTRESS FILL SECTION

SCALE: 1" = 20'


2005 1 14


2005 1 15


2005 1 15


2005 1 19


STARBUCKS
COFFEE
Careful, the beverage you're
about to enjoy is extremely hot.


Dung
STARBUCKS
COFFEE

Lessons Learned

1. Anticipation: I should have anticipated that this could be a concern and have fully briefed the RE
2. Coordination: Even experts need to work through people experienced at the site
3. Communication: We did a poor job apprising the locals of what we were doing and why


Thank you
2005 2 23

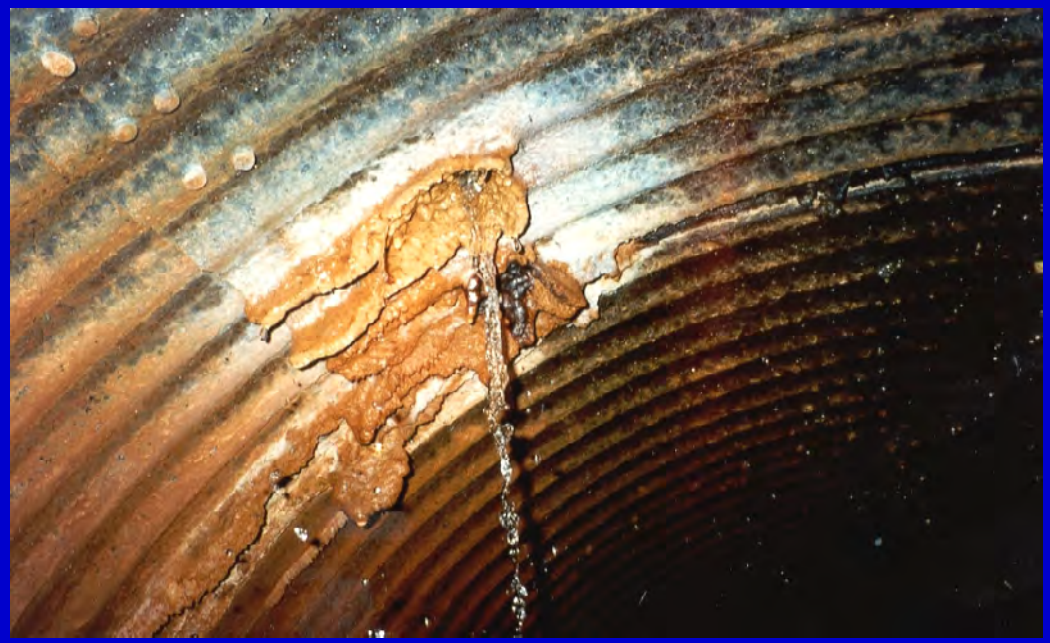
Best Practices for Conduits through Embankment Dams



Chuck R. Cooper
U.S. Bureau of Reclamation

Condition assessment

Tens of thousands of conduits through embankment dams in the United Sates are aging and deteriorating



Condition assessment

These conduits pose an increasingly greater risk resulting in dam failure with each passing year



Background

- In 1998, a Federal Emergency Management Agency (FEMA) dam safety workshop was held in Blacksburg, VA to discuss internal erosion associated with conduits through embankment dams

Background

- A research initiative was recommended to develop a guidance document for use by dam engineering professionals to address this growing problem

Conduit Guidance Document

Goals:

- Recommend best practices
- Provide detailed experience
- References
- Case histories

Committee members

Association of State Dam Safety Officials (ASDSO)

Bureau of Reclamation (BOR)

Federal Energy Regulatory Commission (FERC)

Natural Resource Conservation Service (NRCS)

U.S. Army Corps of Engineers (USACE)

Acknowledgments

Primary contributors:

Mark Haynes and Hal Van Aller (ASDSO)
Chuck Cooper and John Cyganiewicz (BOR)
James Evans (FERC)
Danny McCook (NRCS)
David Pezza (USACE)

Topics addressed

- Design and construction
- Problem identification and evaluation
- Inspection
- Maintenance
- Renovation, replacement, repair, and abandonment

General

Conduits are a discontinuity within an embankment dam and can cause:

- Differential settlement of the adjacent earthfill
- Differing compaction around the conduit compared to the rest of the embankment

Discontinuities

Discontinuities can lead to the formation of cracks and other consequences within the embankment dam such as:

- Internal erosion
- Backward erosion piping

Internal erosion and backward erosion piping

- Internal erosion - A general term used to describe all the various erosional processes where water moves internally through an embankment dam

- Backward erosion piping - Characterized by the formation of an open tunnel that initiates at a downstream seepage exit point and progresses back upstream toward the reservoir

Dam failure modes

Internal erosion and backward erosion piping can progress into a number of different modes of dam failure



Dam failure modes

How do conduits contribute to the failure of an embankment dam?

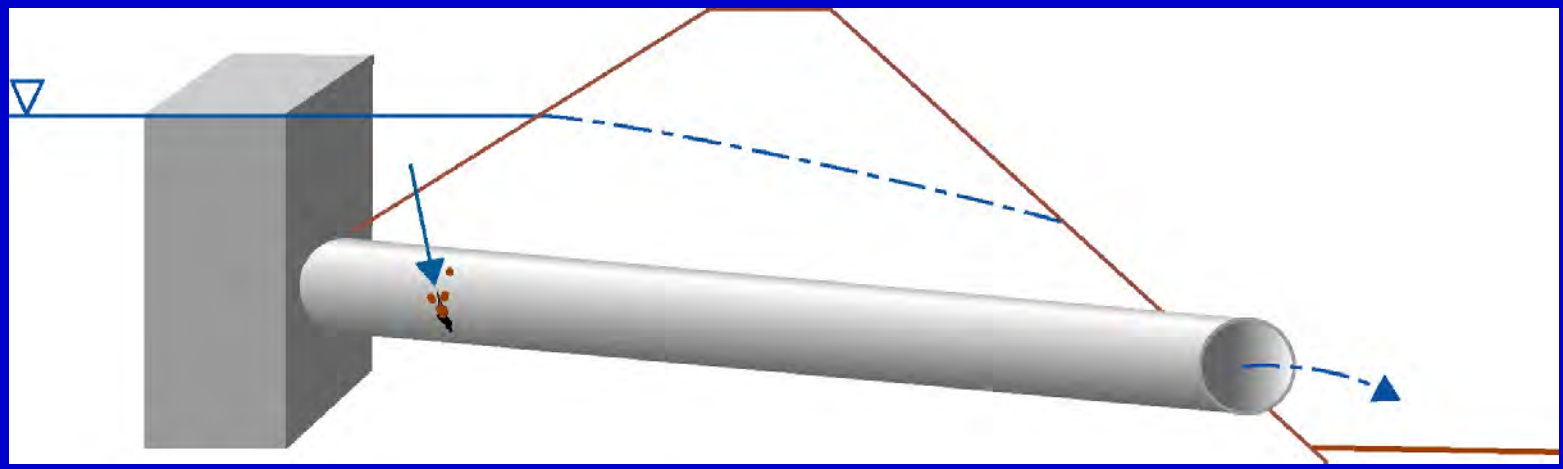
- These failure modes assume no filter protection is provided
- The susceptibility of the embankment to erosion will affect how these failure modes develop

Failure modes associated with conduits

Failure Mode 1: Seepage into a non-pressurized conduit

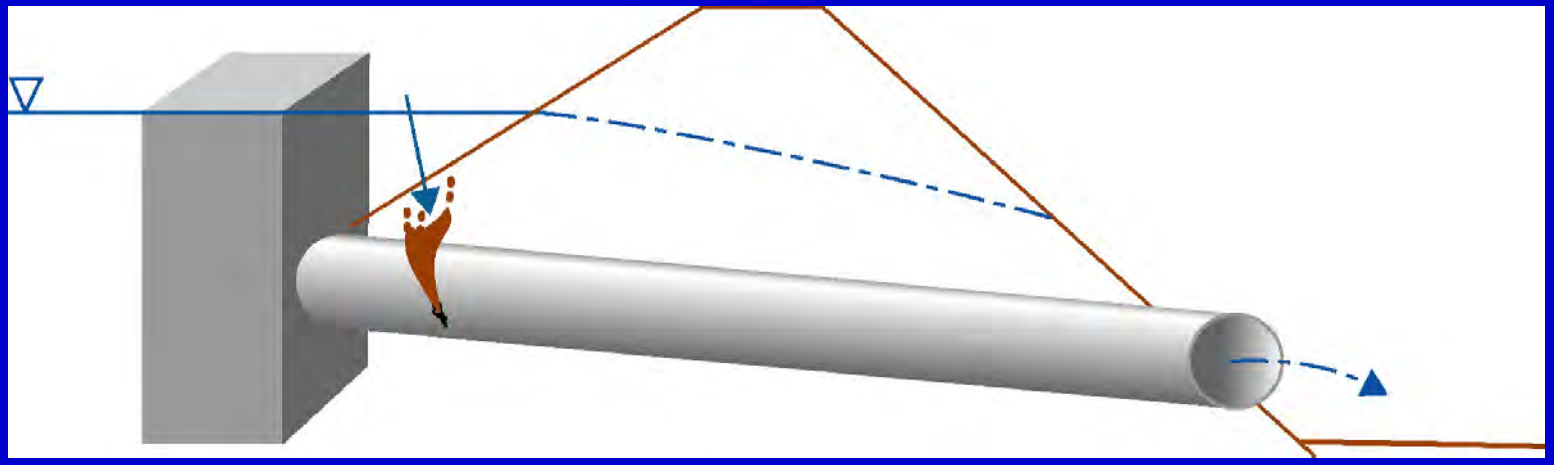
Failure Mode No. 1 - Seepage into a non-pressurized conduit

1. Seepage develops through the dam.



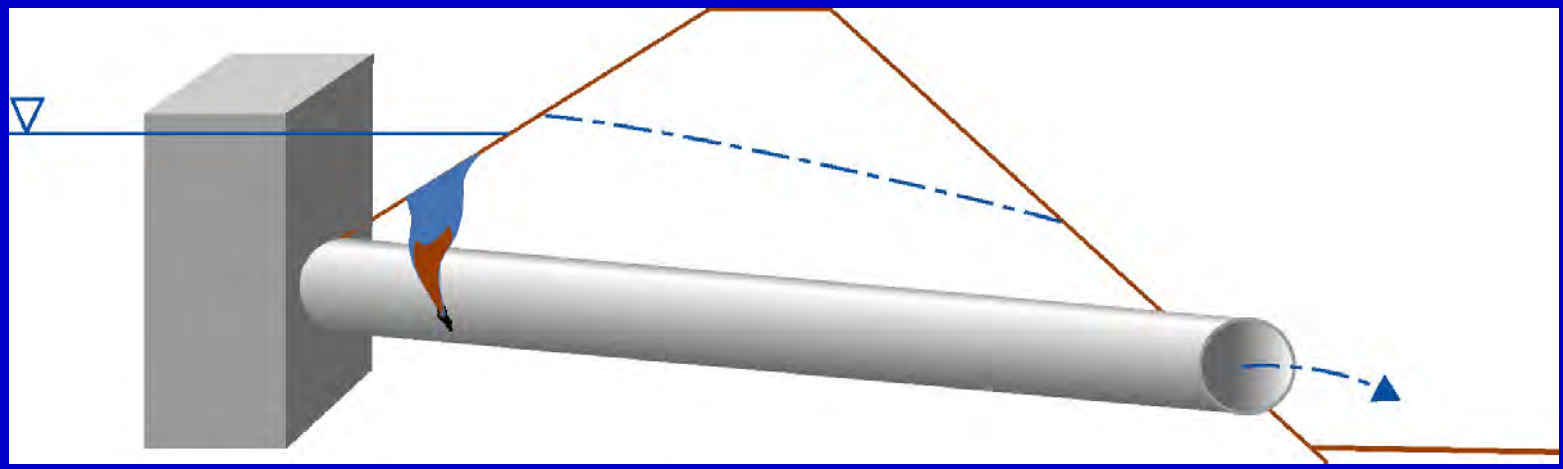
Failure Mode No. 1 - Seepage into a non-pressurized conduit

2. Seepage enters the non-pressurized conduit through a defect.



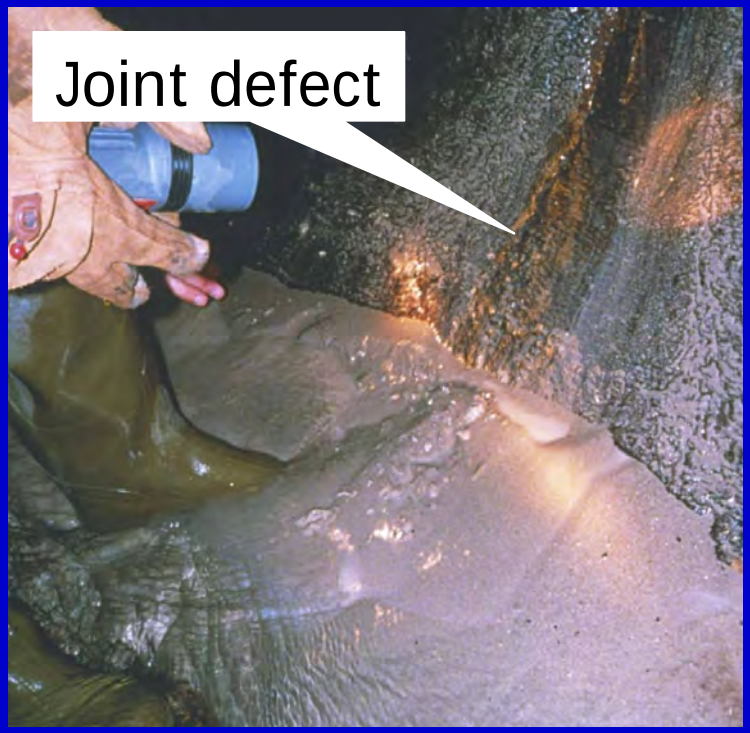
Failure Mode No. 1 - Seepage into a non-pressurized conduit

3. Embankment materials are eroded into the conduit. This can lead to the development of a sinkhole or breach of the dam.



Example of Failure Mode No. 1

Particles of soil have entered the conduit through a joint defect

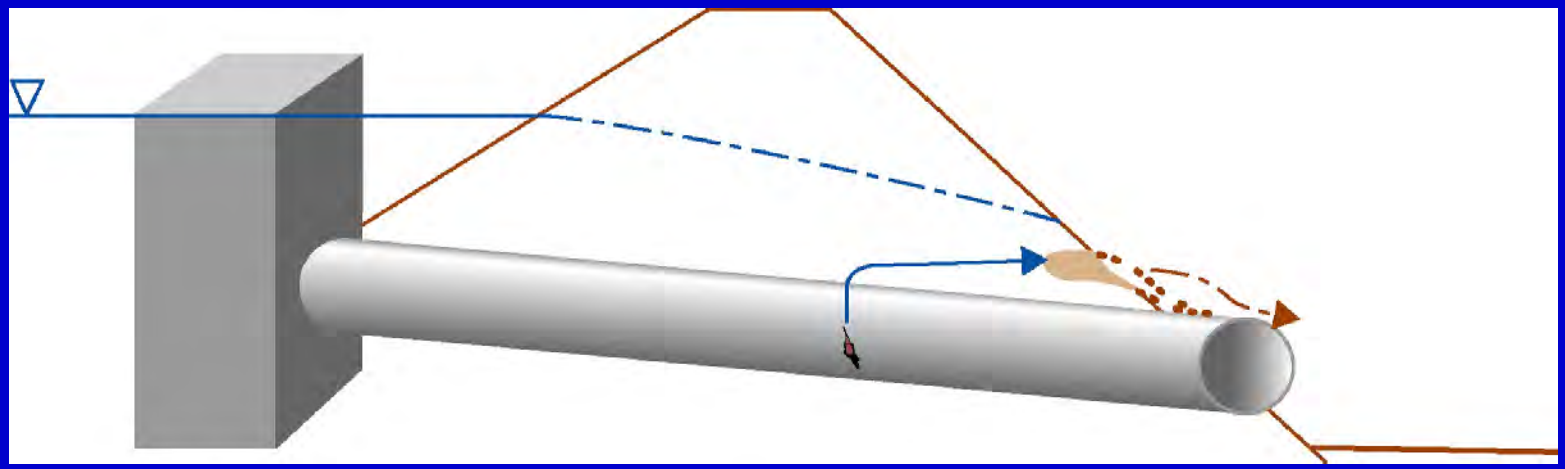


Failure modes associated with conduits

Failure Mode 2: Seepage out of a pressurized conduit

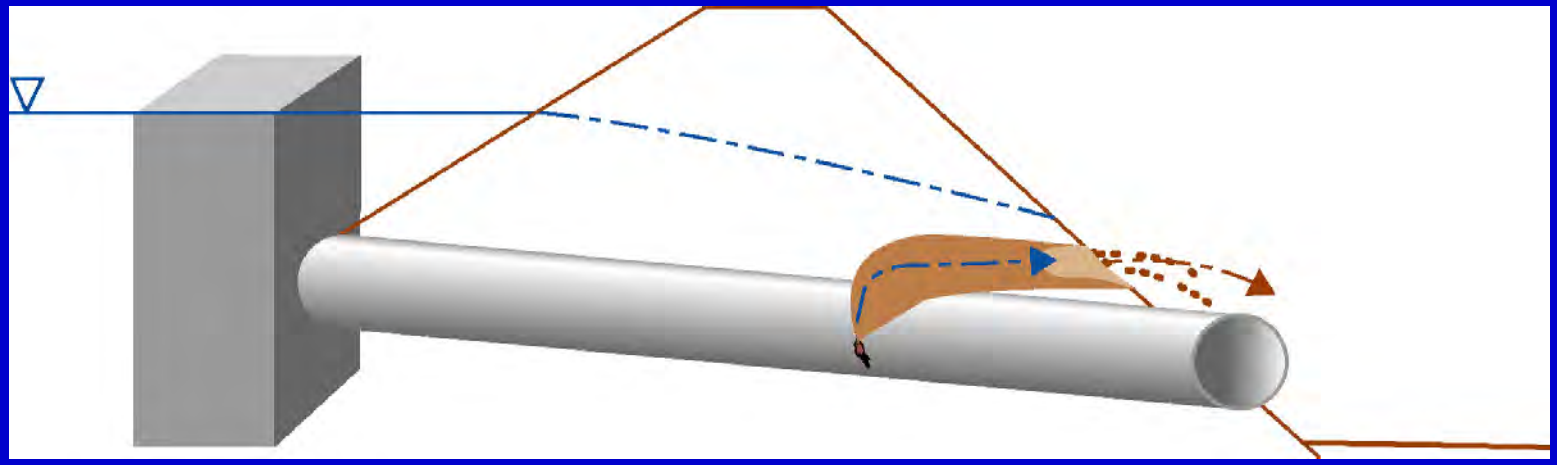
Failure Mode No. 2 - Seepage out of a pressurized conduit

1. Water is forced out of a defect in a pressurized conduit.



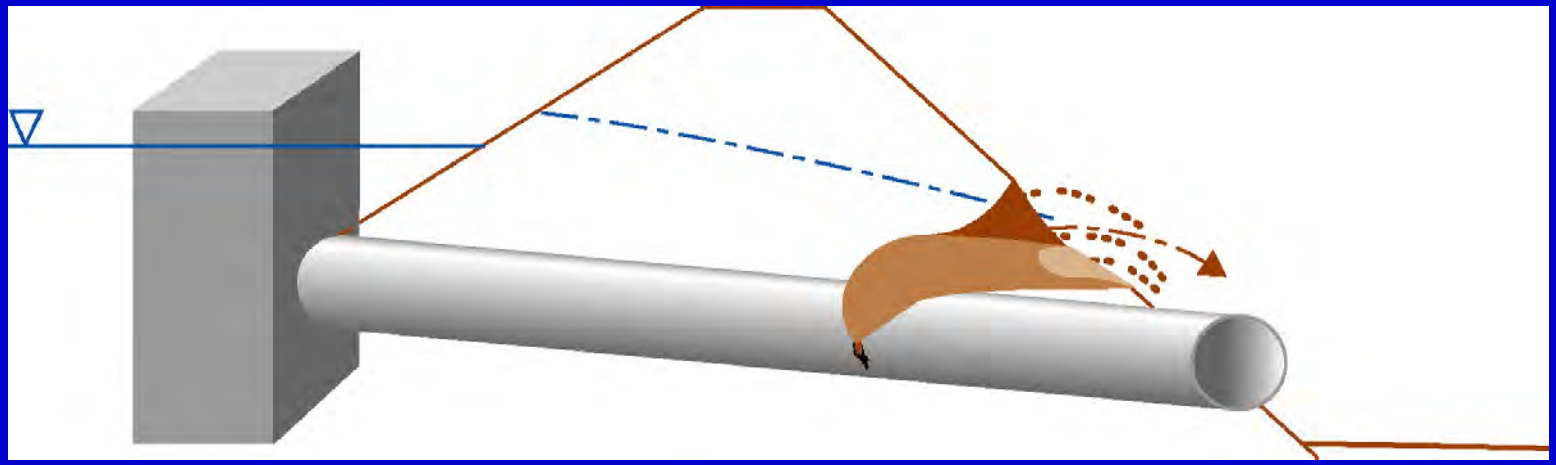
Failure Mode No. 2 - Seepage out of a pressurized conduit

2. Seepage forces carry soil particles to an exit face.



Failure Mode No. 2 - Seepage out of a pressurized conduit

3. Backward erosion piping occurs. This can lead to a breach of the dam.

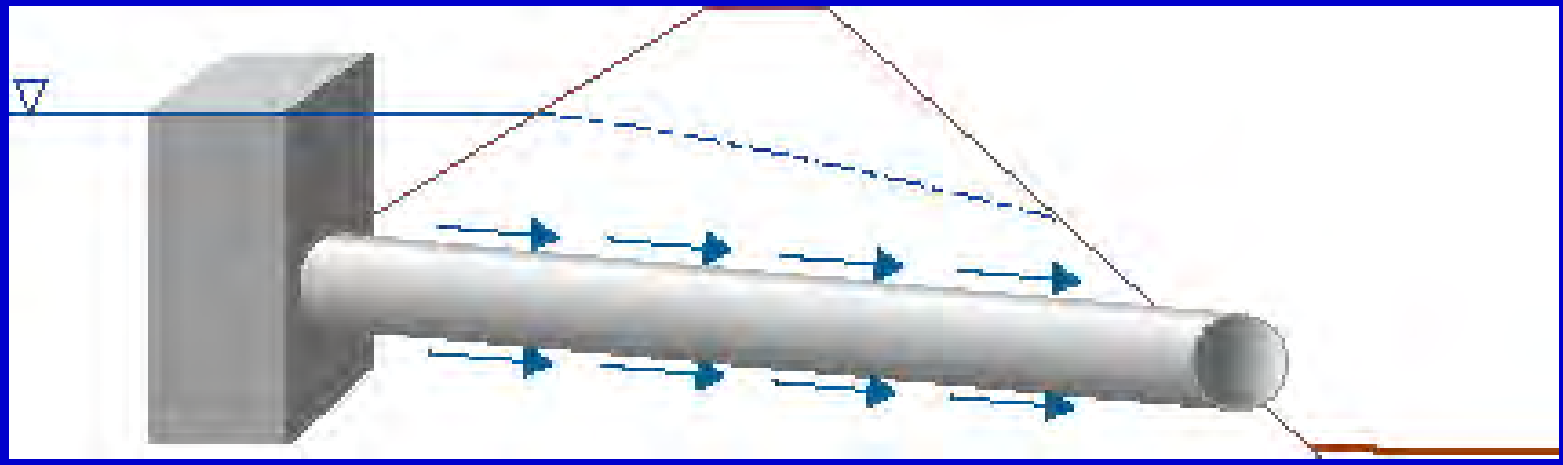


Failure modes associated with conduits

Failure Mode 3: Seepage along the outside of the conduit

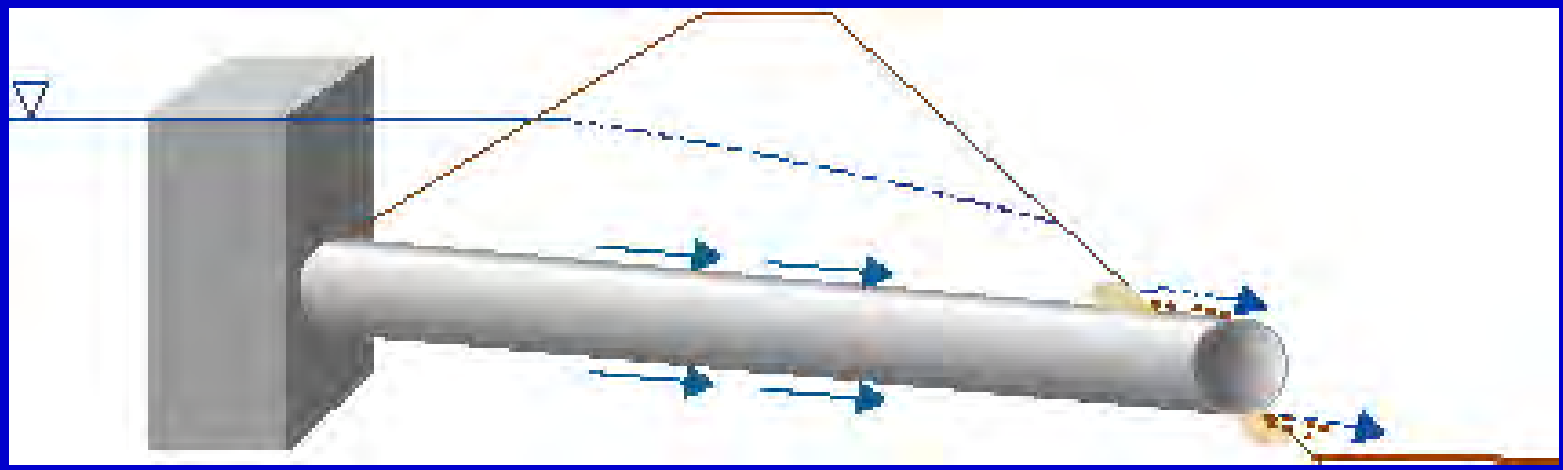
Failure Mode No. 3 - Seepage along the outside of the conduit

1. Seepage develops along the contact between the conduit and surrounding embankment.



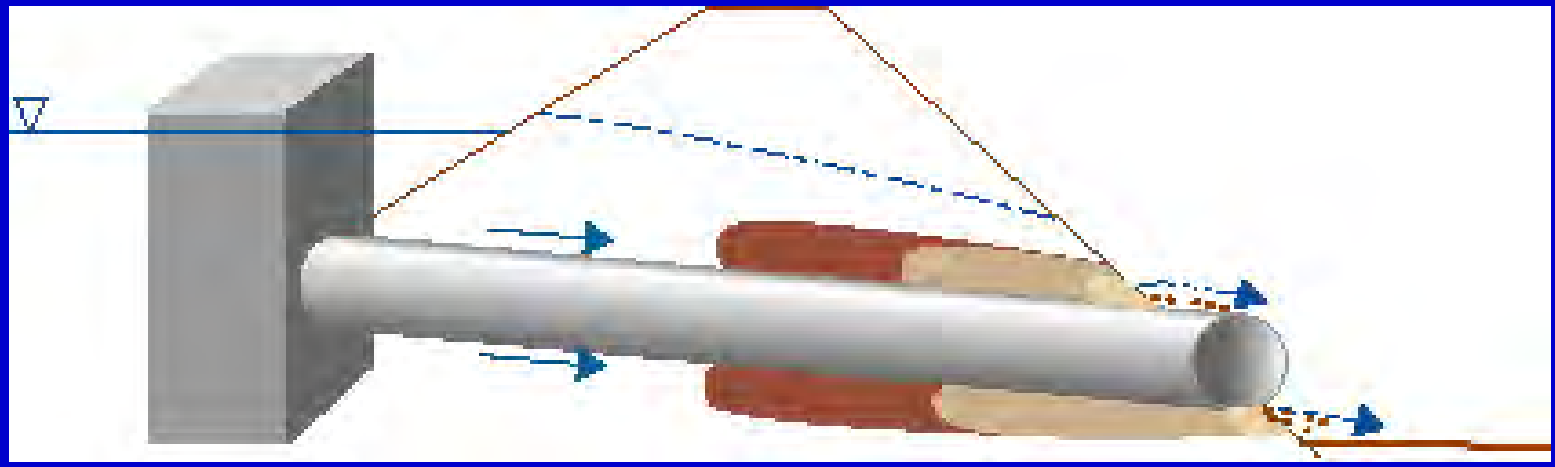
Failure Mode No. 3 - Seepage along the outside of the conduit

2. Seepage erodes soil particles along the flow path.



Failure Mode No. 3 - Seepage along the outside of the conduit

3. Backward erosion piping continues. This can lead to a breach of the dam.

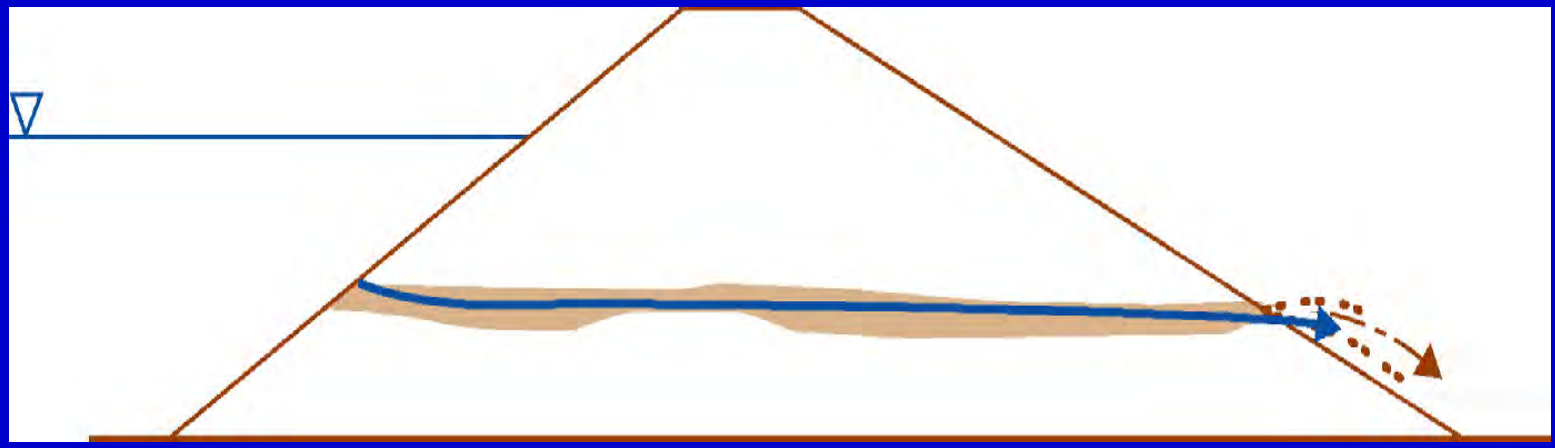


Failure modes associated with conduits

Failure Mode 4: Hydraulic fracture cracks in the earthfill adjacent to the conduit

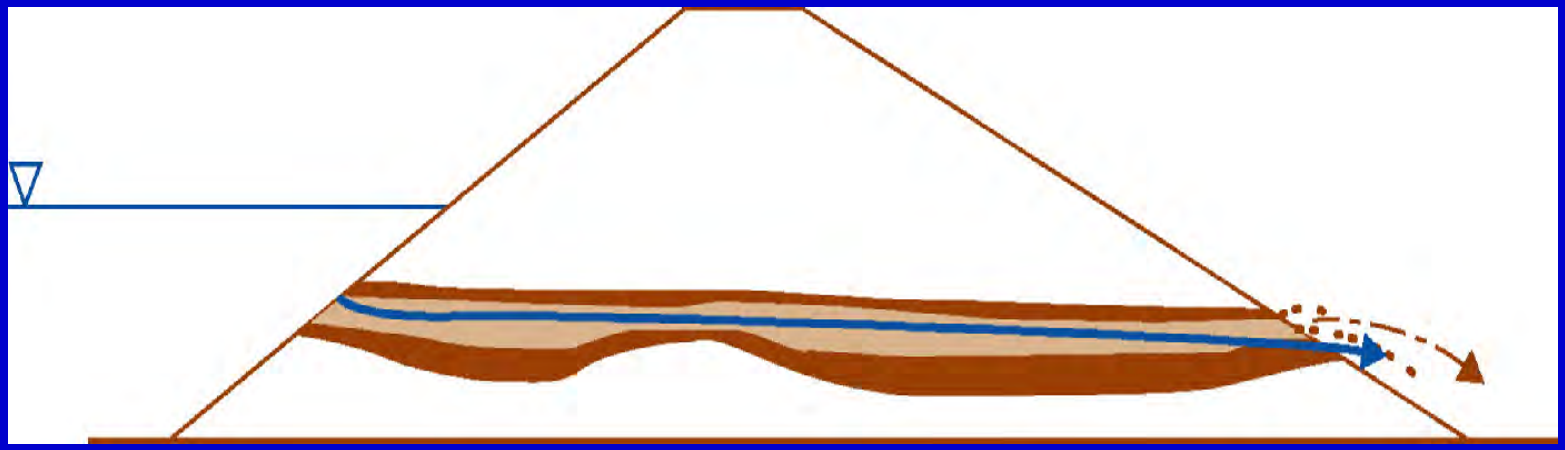
Failure Mode No. 4 - Hydraulic fracture cracks in the earthfill

1. Internal erosion rapidly enlarges a hydraulic fracture crack near the conduit.



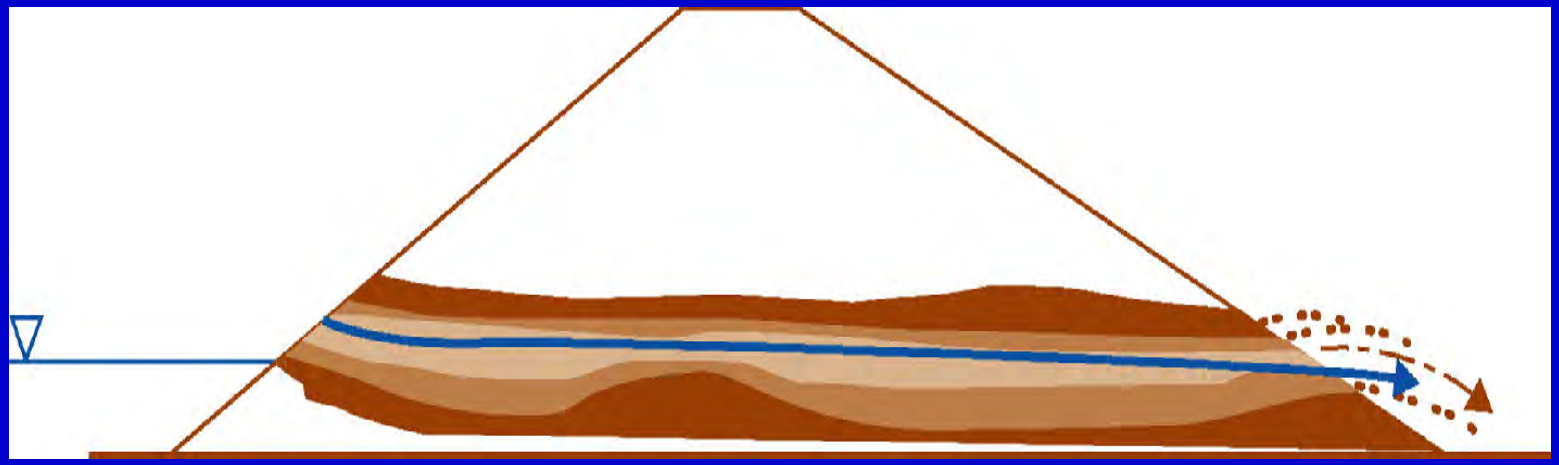
Failure Mode No. 4 - Hydraulic fracture cracks in the earthfill

2. An erosion tunnel develops along the crack.



Failure Mode No. 4 - Hydraulic fracture cracks in the earthfill

3. Continued erosion can lead to a breach of the dam.



Failure Mode No. 4 - Hydraulic fracture cracks in the earthfill

This dam failed due to internal erosion of hydraulic fracture cracks upon first filling



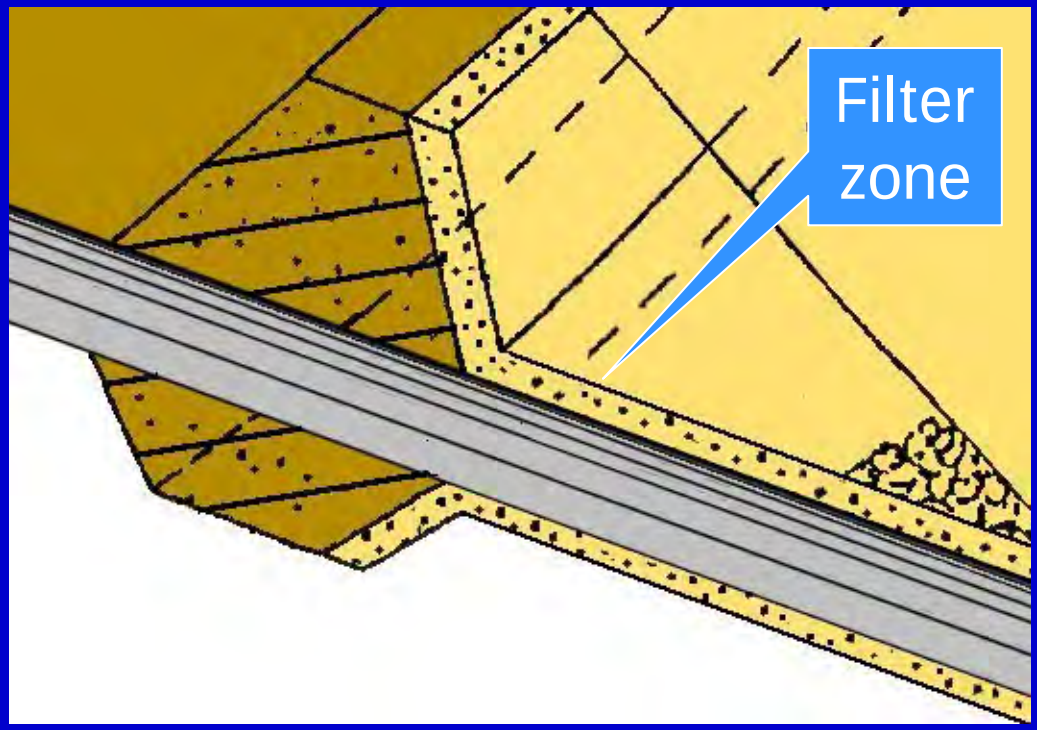
Defensive measures

Use of antiseep collars was discontinued in the 1980's by most of the major dam building organizations



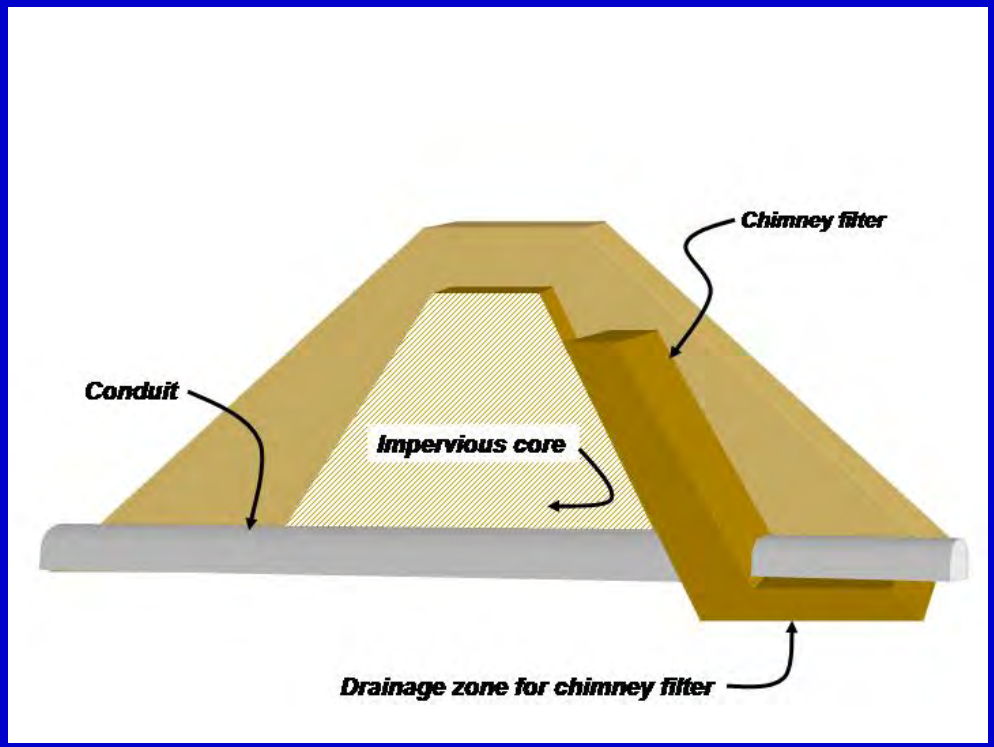
Filter zone surrounding the conduit

A zone of filter material surrounding the conduit is now recommended



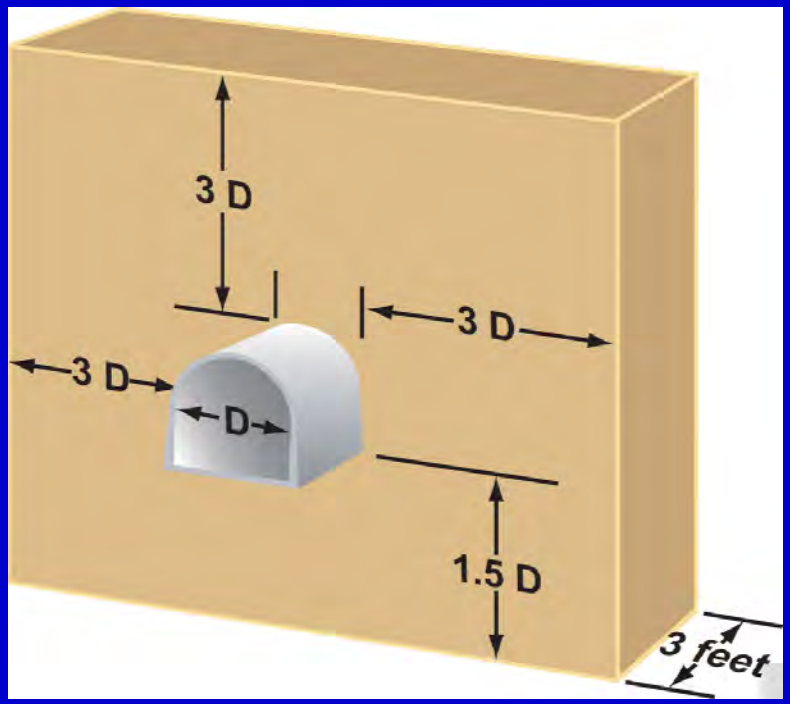
Types of filters used with conduits

Chimney filter – Used in new construction or extensive renovation



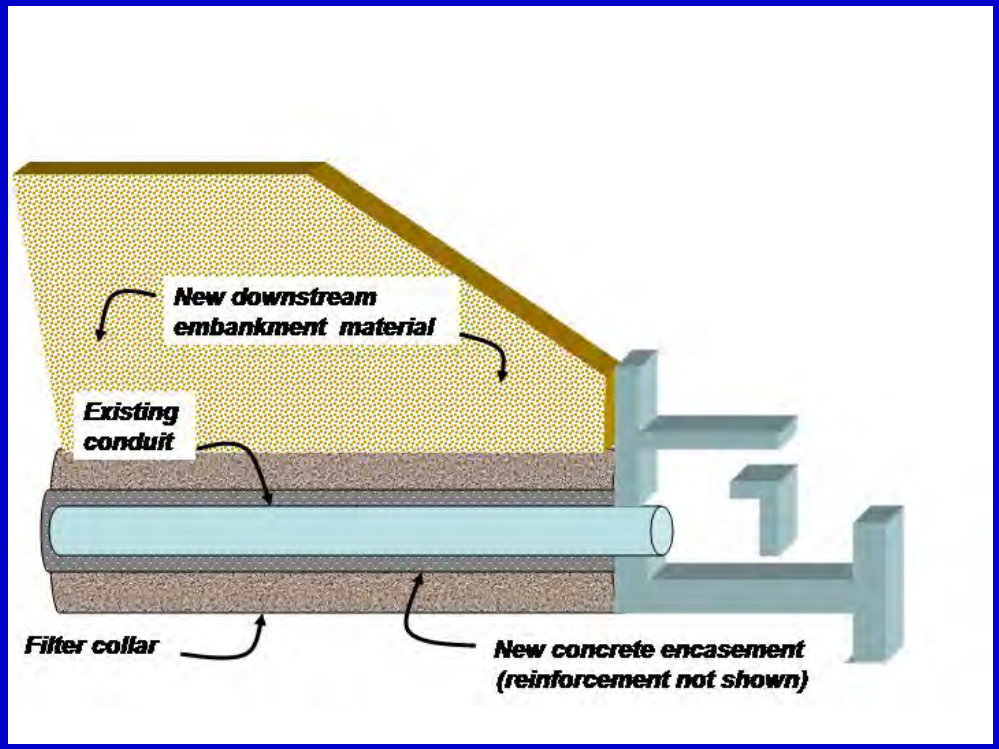
Types of filters used with conduits

Filter diaphragm - Used in new construction or renovation



Types of filters used with conduits

Filter collar – Used in renovation



Conduits

Conduits have been constructed from a variety of materials including:

- Concrete (reinforced cast-in-place, precast)
- Plastic (thermoplastic, thermoset)
- Metal (steel, cast/ductile iron, CMP)

Conduit defects

Each conduit material reacts differently within the dam and is subject to a variety of conditions including:

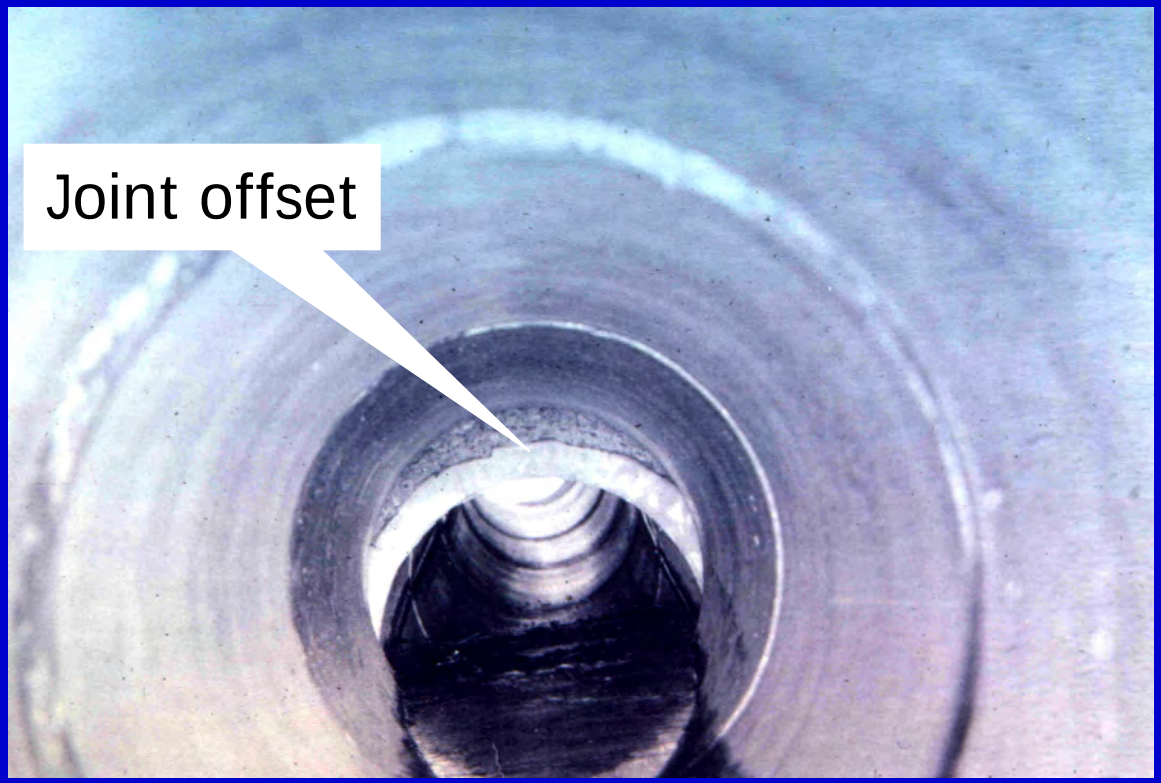
- Deterioration (corrosion, abrasion, aging, cavitation)
- Poor design and construction

Conduit defects - Examples



Corroded CMP

Conduit defects - Examples



Poor design and construction

Common methods of conduit inspection



Man-entry



ROV



Divers



Closed circuit television

Common methods for dealing with problem conduits

- Sliplining
- Remove and replace
- Repair
- Abandonment

Sliplining

High density polyethylene (HDPE) and steel are commonly used



HDPE



Steel

Cured-in-place pipe (CIPP)

Also known as an “elastic sock”



Unloading



Inversion process

Remove and replace



Excavation of the existing conduit



Construction of a new conduit

Repair



Spot repair



Grout injection

Abandonment

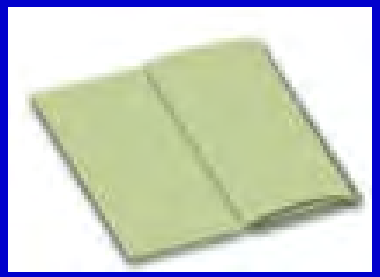
Injection of grout into an existing conduit



Outlet works

Best Practices for Conduits through Embankment Dams

The guidance document will be available for free public distribution in the Fall of 2005.



Hard Copy



CD and DVD

Best Practices for Conduits through Embankment Dams

Information on how to obtain a copy of the document will be posted on FEMA's website at www.fema.gov/fima/damsafe/resources

or

Contact Chuck Cooper (Bureau of Reclamation) at ccooper@do.usbr.gov.

Questions



An Overview of Criteria Used by Various Organizations for Assessment and Seismic Remediation of Earth Dams



2005 Tri-Service Infrastructure Systems Conference and Exhibition

St. Louis, Missouri

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Presentation Overview

- Purpose
- Background
- Issues
- Approach to This Study
- Interpretation by Various Agencies
- Comparison of Agency Criteria
- Summary

Purpose of This Study

- How do you assess liquefaction?
- How do you assess resulting deformations?
- How do you adequately remediate for predicted seismic damage?
- What do USACE guidance documents suggest?
- What do other dam safety entities suggest?

Purpose of This Study





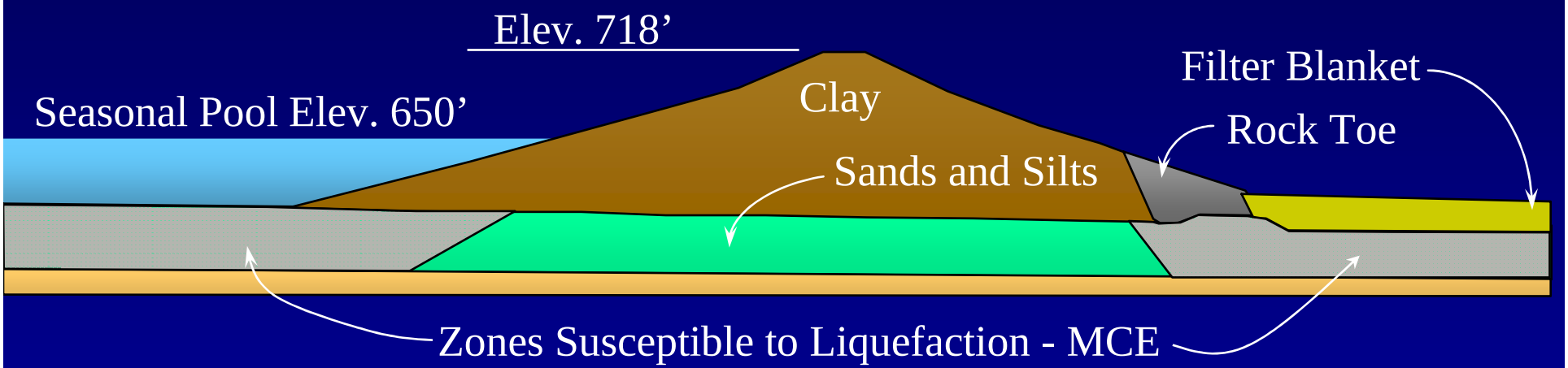
Dewey Dam

Big Sandy River Basin

Prestonsburg, Kentucky

USACE Huntington District

Purpose of This Study



What qualifies as failure?
What level do I remediate to?

The Issues

- Liquefaction Triggering Potential
- Residual Soil Strengths and Post-Earthquake Stability
- Expected Permanent Deformations
- Adequacy of Solution (i.e., assessing risk)

Complex Failure Mechanisms +
Sensitive Response to Input Parameters +
Risk of Catastrophic Failure +
Huge Remediation Costs =
A Challenging Problem

Liquefaction Triggering

$$FS = \frac{\text{Cyclic Resistance Ratio, CRR}}{\text{Cyclic Stress Ratio, CSR}}$$

$$CRR = \left(\frac{\tau}{\sigma'_{vo}}\right)_{Liquefy}$$

$$CSR = \left(\frac{\tau}{\sigma'_{vo}}\right)_{Loading}$$

} Same Density & No. of Load Cycles

Liquefaction Triggering

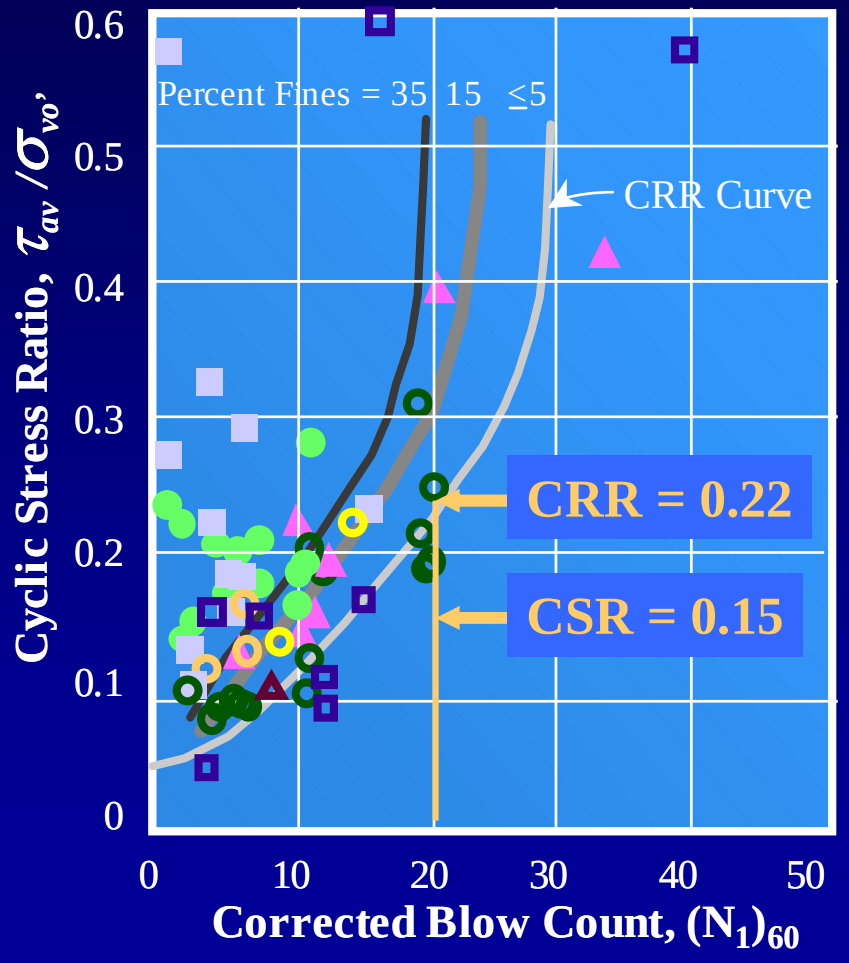
$$FS = \frac{CRR}{CSR} \times MSF \times K_{\alpha} \times K_{\sigma}$$

MSF = Magnitude Correction

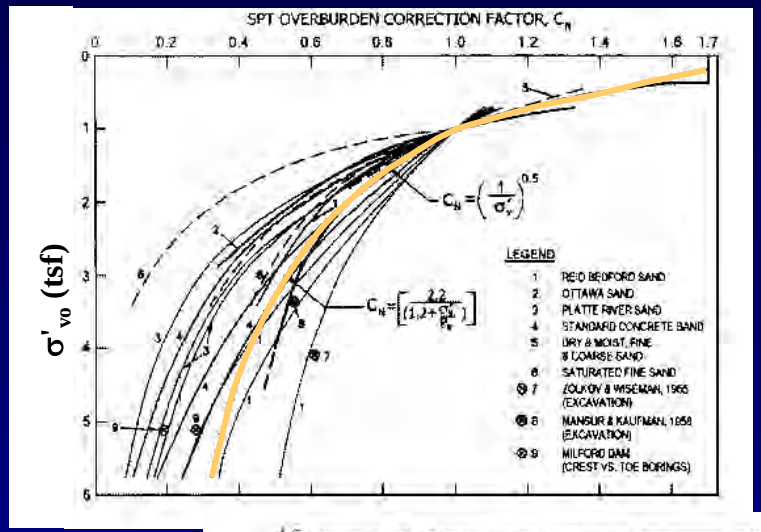
K_{σ} = Confinement Correction

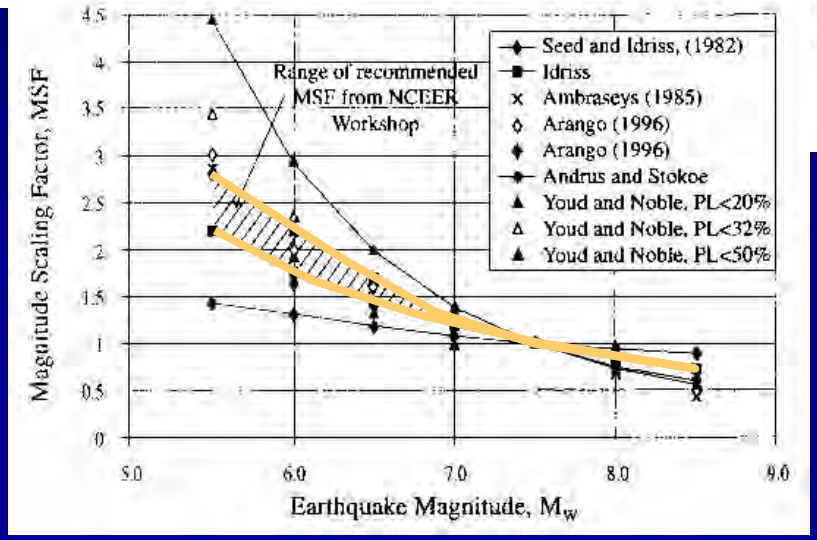
K_{α} = Shear Stress Correction

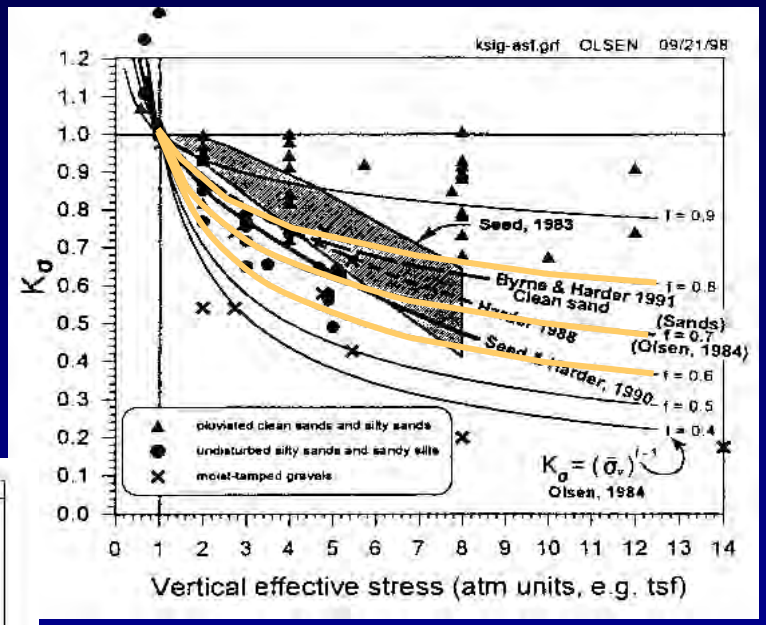
$$\mathbf{FS = \frac{0.22}{0.15} = 1.5 \times \ldots}$$



Liquefaction Triggering

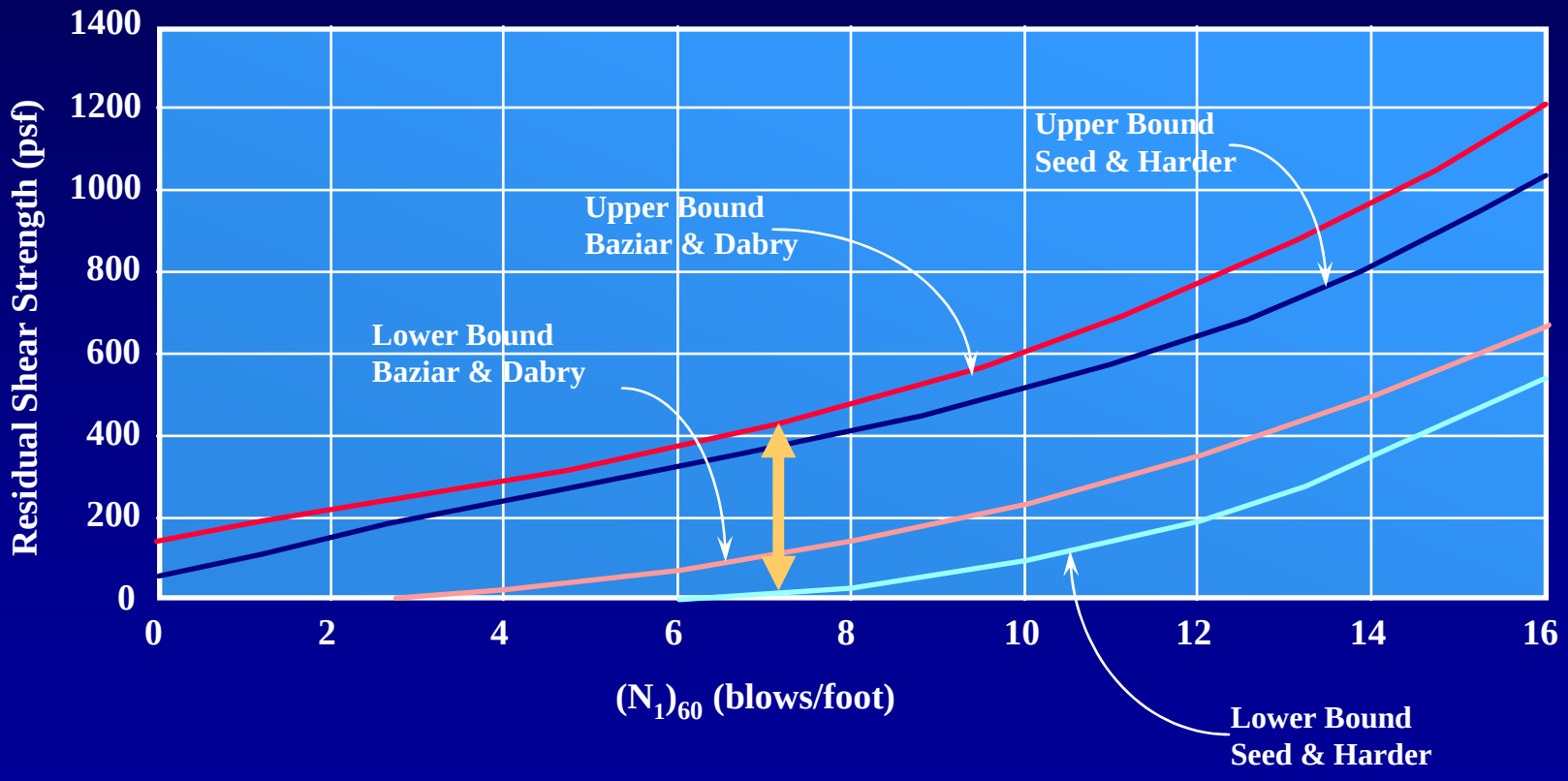




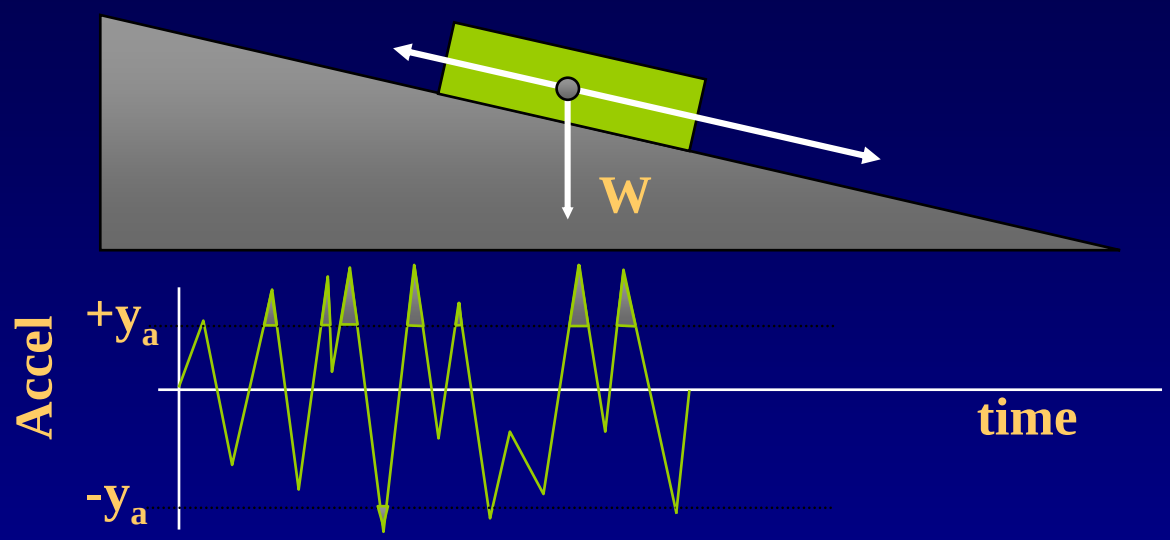


ASCE, JGGE, 10/2001

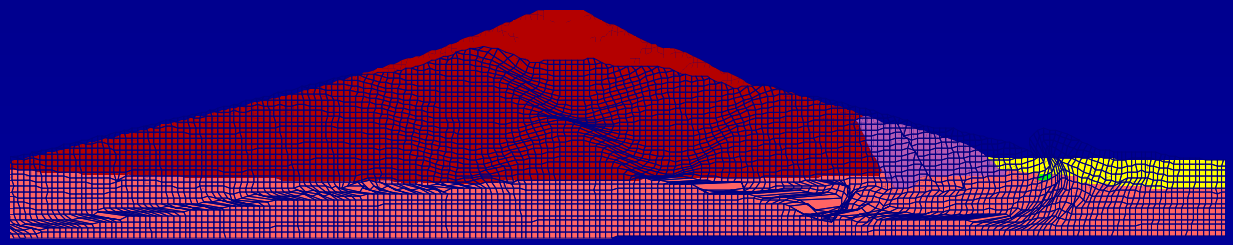
Residual Soil Strengths



Permanent Deformations

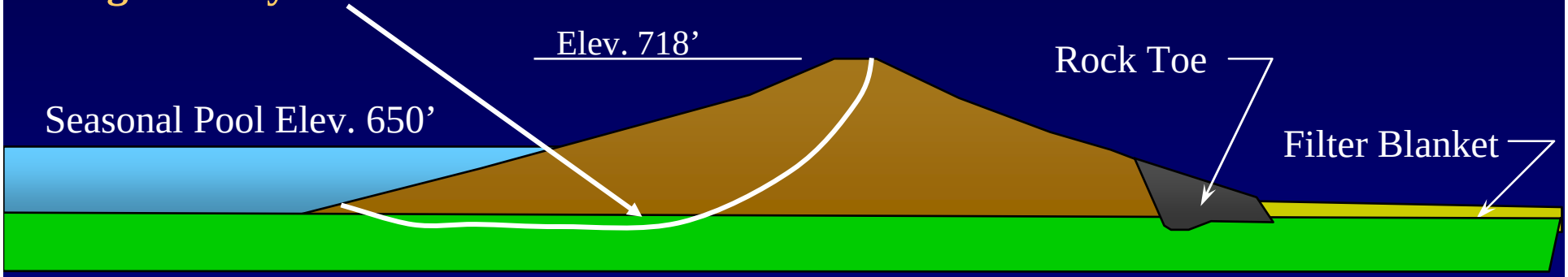


Newmark's Method or Numerical Modeling?

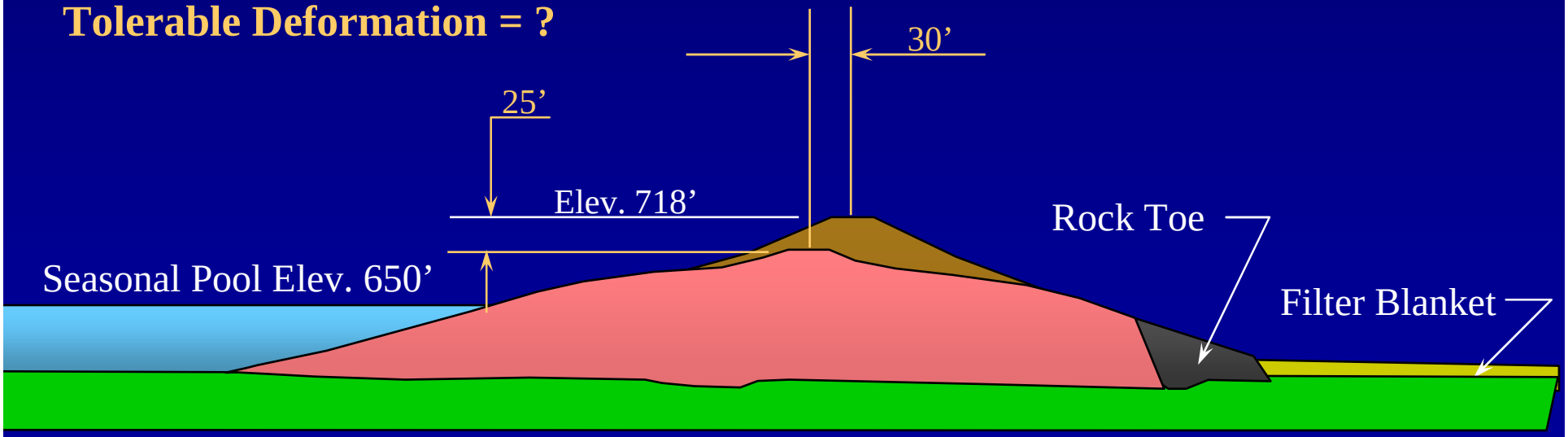


Judging Adequacy of Analyses or Designs

Target Safety Factor = ?



Tolerable Deformation = ?



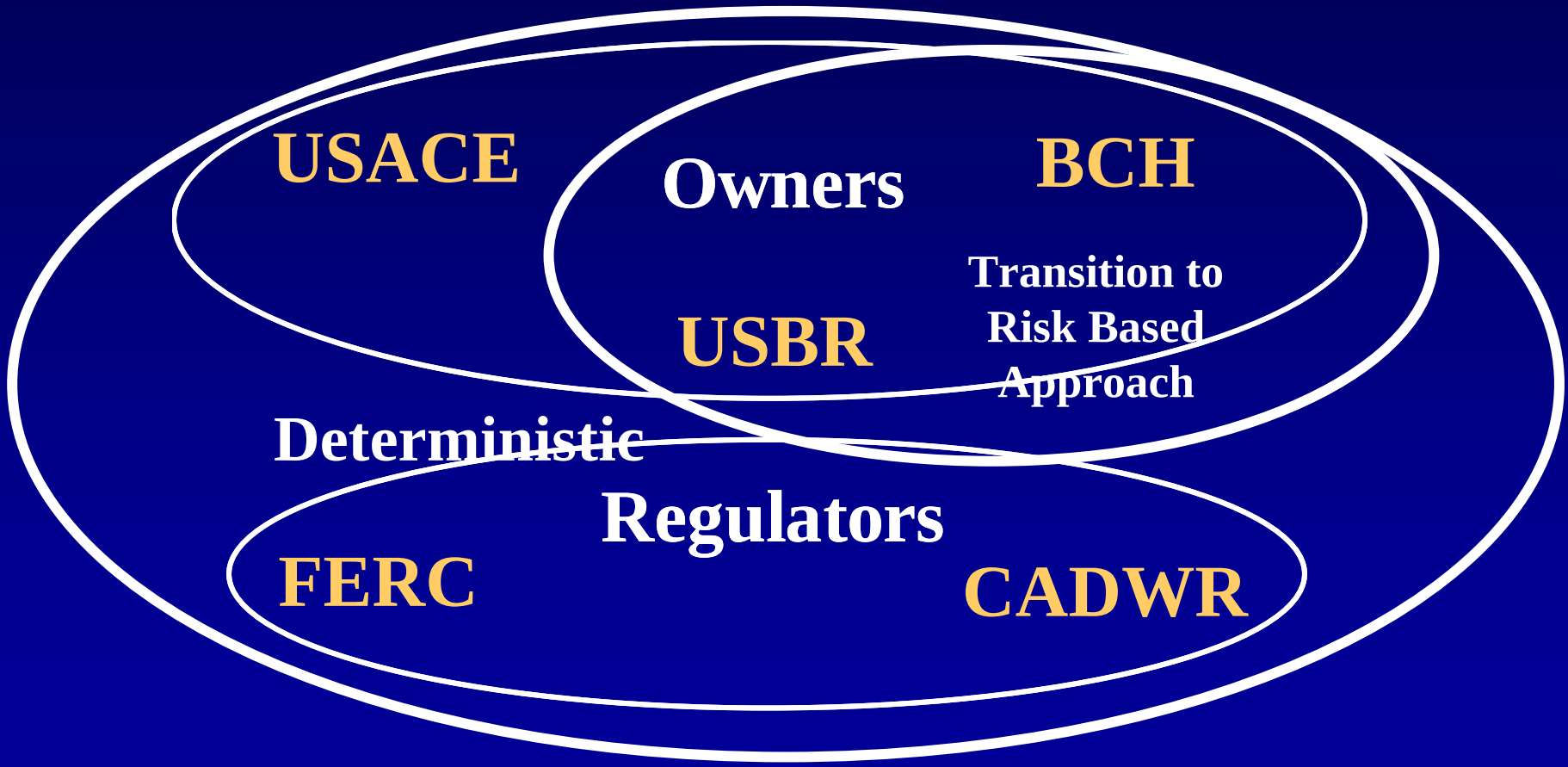
Approach to This Study

- Research how USACE and other agencies address the following:
  - Liquefaction Triggering Assessment
  - Liquefied Soil Residual Strength Assessment
  - Permanent Deformation Assessment
  - Adequacy Assessment for Existing or Remediated Structure
- Interviews, Review of Guidance Documents and Other Publications
- Current as of 2001

The Agencies

- U.S. Army Corps of Engineers (USACE)
- U.S. Bureau of Reclamation (USBR)
- Federal Energy Regulatory Commission (FERC)
- California Department of Water Resources (CADWR)
- British Columbia Hydro (BCH)

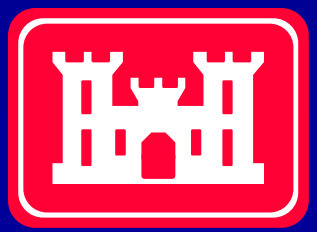
Criteria of Various Agencies



USACE Approach

Phase II Special Study

- Gather required data.
- Deterministic analysis for MCE.
- Complete liquefaction analyses.
- Establish post-liquefaction strengths.
- Perform static limit equilibrium (LE) analyses.
- Perform finite element (FE) deformation analyses.
- Use LE and FE to evaluate remediation alternatives.



USBR Approach

- Incorporating risk based methodologies.
  - MCE (Probabilistic or Deterministic)
  - Potential fatalities
  - Confidence in data
- Ground motion frequency content "matched" to structure
- Use total stresses to evaluate liquefaction potential.
- Require higher post-earthquake LE safety factors.
- Remediate based on probability and consequences of failure.

FERC Approach

- Deterministic analysis for MCE.
- Low confidence in numerical modeling, relying on Newmark type analyses.
- Deformations limited to 2 feet (some exceptions).
- Deformations considered valid only for Post-Earthquake Limit Equilibrium FS > 1.0

CADWR Approach

- Deterministic analysis for MCE.
- Low confidence in numerical modeling, relying on Newmark type analyses.
- No observed performance to compare with numerical model predictions.
- Deformations considered valid only for Post-Earthquake Limit Equilibrium FS > 1.0.
- Often dealing with gravels, use BPT.

BCH Approach

- Probabilistic analysis for MCE.
- Incorporate variability in input parameters.
- Do employ numerical modeling.

Comparison of Approaches

Comparison of Criteria Proposed by Various Agencies.					
	USACE	**USBR**	**FERC**	**CADWR**	**BCH**
Basis for MCE	Determin-istic	Both	Determin-istic	Determin-istic	Probabil-istic
Total or Effective	Effective	Total	Effective	Total	Total
Safety Factor	>1.0[1]	1.05 to 1.20[2]	>1.0	>1.0	>1.0
Newmark or Num. Modeling	Both	Both	Newmark	Newmark	Both

[1]Exceptions made on a case by case basis.

[2]SF=1.20 is applicable when best estimate of post-earthquake strengths. SF=1.05 is used for worst case estimate of post-earthquake strengths.

Summary

- Challenging and Inexact Analyses
- Owners vs. Regulators
- Probabilistic vs. Deterministic
  - Selecting Ground Motion
  - Quantifying Loss of Life
  - Evaluating Risk Among Different Structures
  - Evaluating Critical Failure Modes
- Deformation Analyses vs. Observed Performance

Speaker Information

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Fuller
Mossbarger
Scott &
May

FMSM ENGINEERS

National Defense Industrial Association

2005 Tri-Service Infrastructure Systems Conference

"Re-Energizing Engineering Excellence"

August 2-5, 2005

Iwakuni Runway Relocation Project



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MCAS Iwakuni
2000/2010 – A Reality



2000

2010



Background

- US & Japan signed MOU Jul 1992
  - 3 spheres of communication/oversight: Politicians, Regional & Senior Managers, & lastly, the project team
- Primary reasons for project
  - Reduce noise in City of Iwakuni
  - Improve flight safety of Airfield
- (Unstated) impact ….Commercial Use possibility
- Explosives Safety SEC CERT approved current plan in Mar 2000 – revisions being reviewed
- GOJ project cost estimate $2.4B
- Project in year 9 of 13
  - Phase I reclamation complete
  - Phase II reclamation in progress
  - Port Area to complete in June 2005; Fuel Wharf in July 2005
  - $1.852B spent or authorized through JFY2005; $2.082B projected after JFY2006
- Detailed Criteria Package conveying US military expectations

Project Background/Requirements (Continued)

- 8000’ Class B runway (with 1,000 foot overruns)
  - Hot-pit refueling
  - Simultaneous CALA and Red Label area operations
  - State-of-the-art aviation navigational aids
  - 1,000 foot overruns; US MCON must fund hardened overrun
  - Concrete pavement required due to heat signature of US military aircraft
    - F/A-18, AV-8B,
- Port Facilities
  - 360 Meter General Purpose Wharf - minimum 42’ draft, 80T rail crane
  - 142 Meter North Breakwater Wharf - minimum 60’ draft, 100,000 lbs NEW
  - T-1 capable Fuel Wharf
  - New staging/container lay-down areas and warehouses.
- New Ordnance Storage Area eliminates explosives safety waivers

Reclaimed Land: Sand Piles & Sand Drains Construction



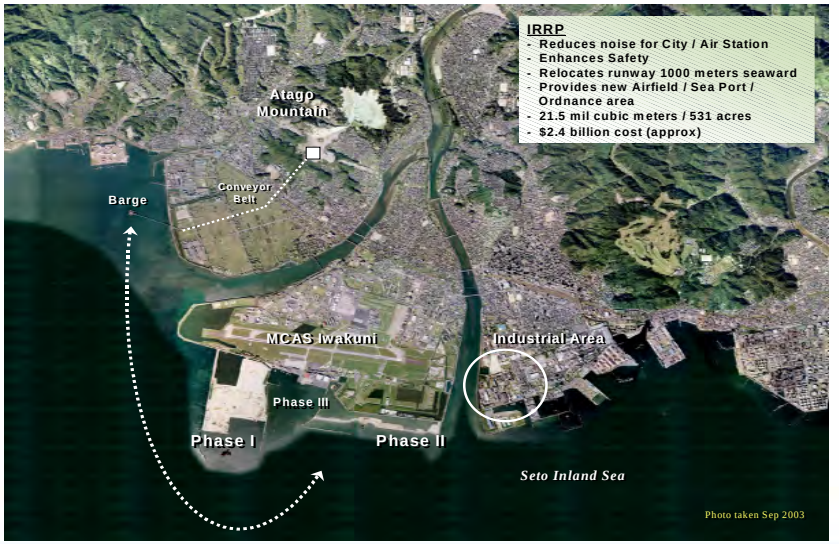
Crushed Rock Conveyed from Atago Mountain by Barge



SAND COMPACTION PILE AUGERS



Sand Piles: Liquefaction Prevention from Tight Consolidation
Sand Drains: Uniform, Loose Consolidation



Construction Progress Photos





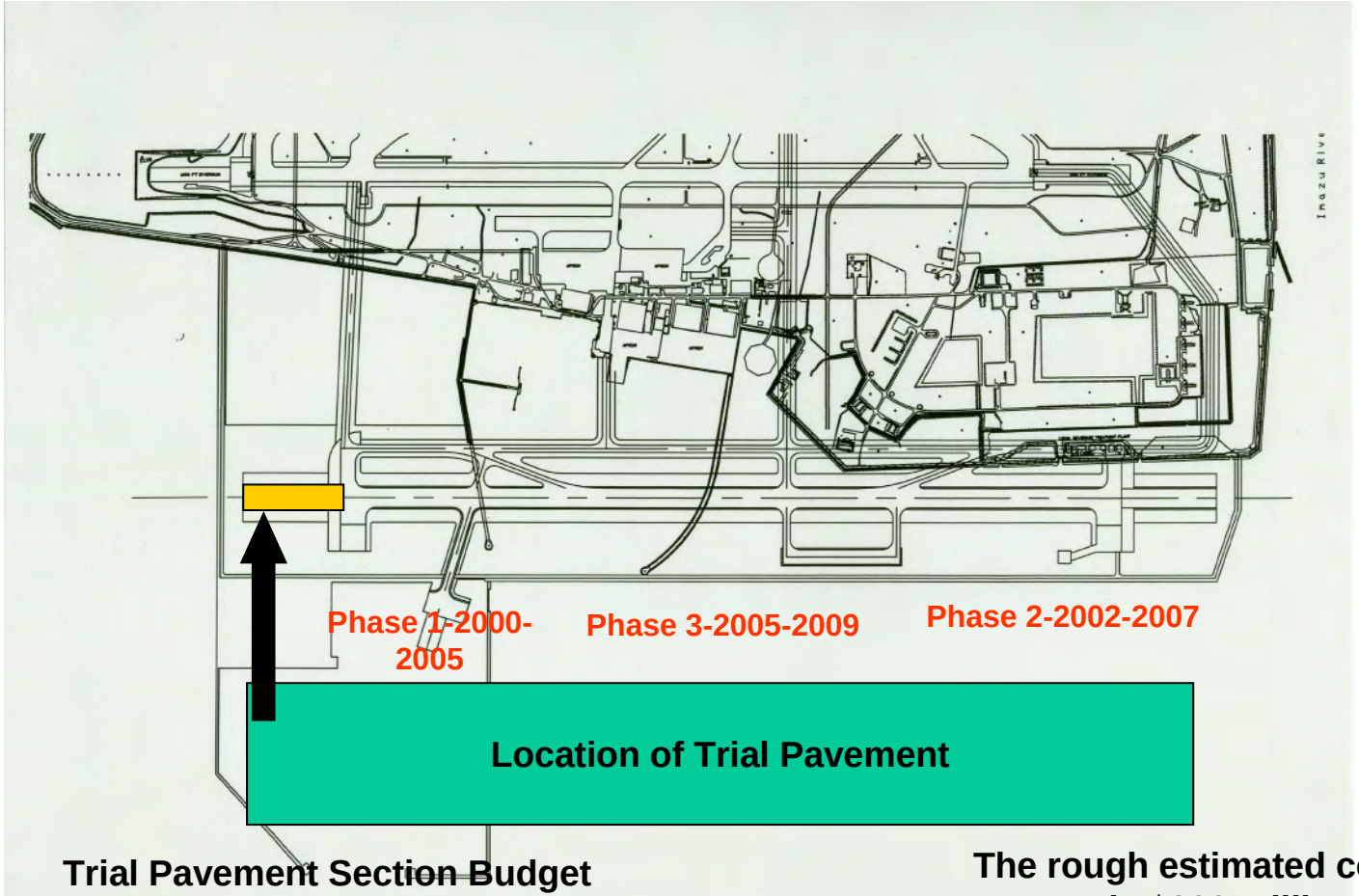




Civil Engineering Features for Runway Construction

- **Flat Surface Criteria:** This construction requires a smooth pavement for the runway on the reclamation area anticipating a consolidation settlement which will occur over many years.
- **Settlement:** Uneven (differential) Settlement Amount: about 6cm at 50m intervals
  - Sand Piles/Sand Drains
  - 3 phases of consolidation
- **Unpredictable Soil Behavior:** The result of how the concrete pavement, compacted sub grade, and sand piles/sand drains will perform due to uneven residual settlement at reclamation area is not known at this time.
- **Material Parameters:** Type of concrete pavement (CRC, reinforced concrete or NC, non-reinforced concrete) and base course and the final design thick nesses of concrete slab will be determined based on demonstration section results
- **Design Procedure Parameters:**
  - GOJ developing their own design procedures; US to review using our tools. We need to verify what happens to the concrete slab during the test period
  - Current concept of design cannot be verified until the testing of actual conditions occurs.
  - Ground Settlement must be better understood by analyzed data gathered during test period for final pavement design

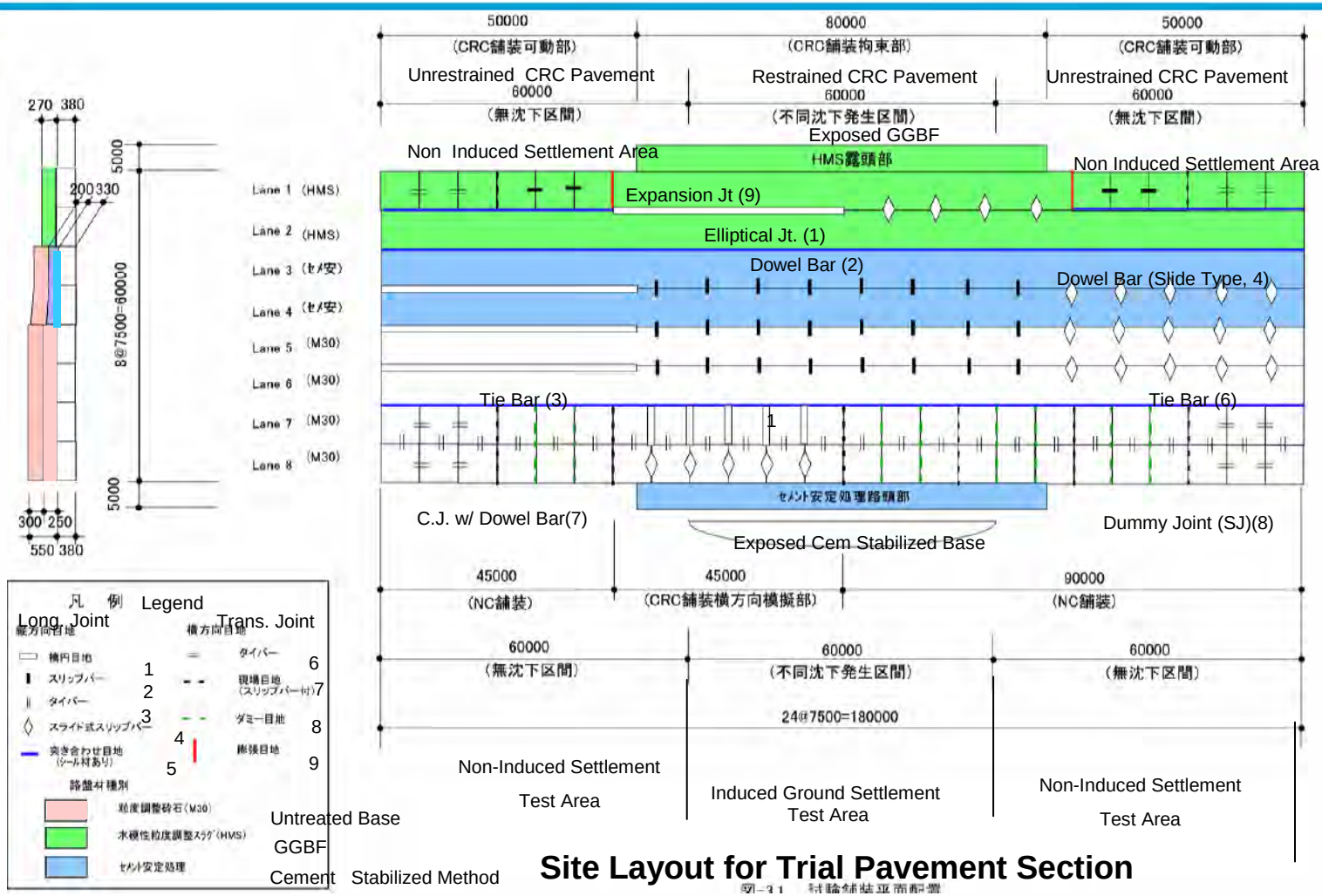
Test Section



Trial Pavement Section Budget
Cost: $10 Million Funded by GOJ

The rough estimated cost of the runway is $200 million

Test Section



Site Layout for Trial Pavement Section

Pavement Type	Lane
Normal PCC	Lane 8
CRC	Lane 1--7

Ground Gran. Blast Furn. Slag

Ground Gran. Blast Furn. Slag

Cement Stabilized Method

Cement Stabilized Method

Untreated Base

Untreated Base

Untreated Base

Untreated Base

Pavement Joints Types:

Longitudinal	
Elliptical	1
Dowel Bar	2
Tie-Bar	3
Dowel Bar (Slide Type)	4
Butt Joint w/seal	5
Transverse	
Tie-Bar	6
C.J. w/ Dowel Bar	7
Dummy Joint (SJ)	8
Expansion Jt	9

TEST SECTION





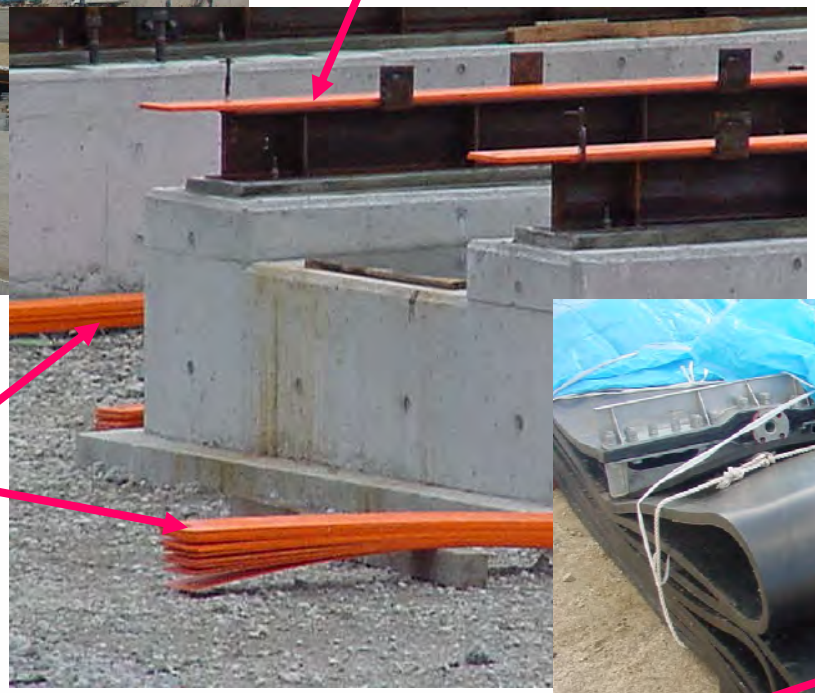
Steel Grillage for Introducing Differential Settlement



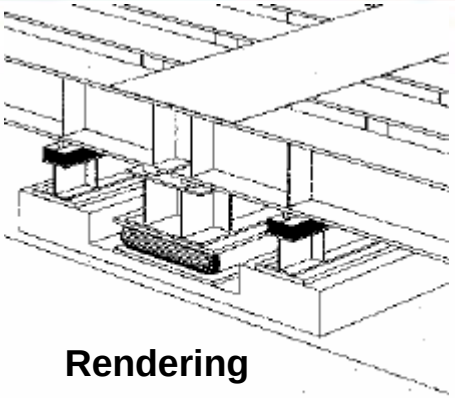
Platform for placement of Pavement structure

TEST SECTION





Shim Stack Location



Rendering

Shim stack



Water bag for jacking

Test Section Objectives

- **Purpose: The demo section will be used to determine the effects of artificially induced differential settlement and to understand concrete pavement behavior by applying repetitive loadings and other thermal, drying stresses.**
- **Pavement Loading**
  - **747 Wheel cart**
  - **Number of repetitions**
- **Slab Instrumentation for load, thermal, & shrinkage stresses**
- **Test Section Cost: $10 million**
- **GOJ/US Government to Use Demo results To Get Final Design Pavement Thickness Right!**


Trial Section with Reinforcing set prior to paving

PAVEMENT SENSITIVITY ANALYSIS

PAVEMENT PROFILE CONDITION	LOADING CONDITION	NAVY PAVEMENT COMPUTED THICKNESS (Inches)	PCASE PROGRAM COMPUTED THICKNESS (Inches)
FLEX 650,SG 100	NAVY	15.0	15.7
FLEX 650,SG 200	NAVY	13.8	14.5
FLEX 650,SG 300	NAVY	13.2	13.2
FLEX 650,SG 500	NAVY	13.0	11.2
FLEX 650,SG 100	AIR FORCE	27.2	20.3
FLEX 650,SG 200	AIR FORCE	25.6	16.8
FLEX 650,SG 300	AIR FORCE	24.7	13.8
FLEX 650,SG 500	AIR FORCE	24.6	11.8
FLEX 726,SG 100	NAVY	14.1	14.8
FLEX 726,SG 200	NAVY	12.8	12.5
FLEX 726,SG 300	NAVY	12.3	10.6
FLEX 726,SG 500	NAVY	12.2	10.7
FLEX 726,SG 100	AIR FORCE	25.6	19.0
FLEX 726,SG 200	AIR FORCE	24.1	15.6
FLEX 726,SG 300	AIR FORCE	23.3	12.9
FLEX 726,SG 500	AIR FORCE	23.1	11.1

Pavement Structure

Item	Sub Item	Test Condition		Remarks
Classification of Pavement		NC,CRCNC Pavement, CRC Pavement		
Concrete	Design Basis Flexural Strength	$5N/mm^2$		
	Elastic Coefficient	$2.75\times10^5N/mm^2$		
	Poisson's Ratio	0.15		
NC Pavement	Slab Thickness	38		C-141 Objective Aircraft
CRC Pavement	Slab Thickness	33cm w/ Cement Treated Base	38cm	C-141 Objective Aircraft
	Amount of Rebar for Longitudinal Direction	D19ctc13cm	D19ctc11.5cm (D22ctc15.5cm)	
	Amount of Rebar for Lateral Direction	D13ctc37cm	D13ctc32cm	
	Depth of Rebar for Longitudinal Direction	11cm 11cm from Top Surface	12.5cm 12.5cm from Top Surface	

Pavement Structure

Base Course Materials	Granular Material Untreated Base	Cement Stabilization	HMS Hydraulic Mechanical Stabilized Slag (GGBF)
Select Materials	Granular Material I CBR Modified CBR 80% Granular Material II CBR Modified CBR<80%	Cement Stabilization $E=5{,}000N/mm^2$	HMS $E=750N/mm^2$
Coefficient of Bearing Factor for Design Sub grade	$K_{75}=$ 24 (MN/m^3)		
Coefficient of Bearing Factor for Base Course	$K_{75}=$ 70	150	70
Coefficient of Bearing Factor for Design Base	$K_{75}=$ 56	120	56

Questions?



2005 Tri-Service Infrastructure Systems Conference and Exhibition
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August 2-5, 2005
St. Louis, MO

Ground-Penetrating Radar Applications for the Assessment of Pavements

Lulu Edwards
Research Engineer
and
Don R. Alexander
Chief, Airfields and Pavements Branch

Airfields and Pavements Branch (APB)
Geotechnical and Structures Laboratory
US Army Engineer Research and Development Center
Vicksburg, MS



Ground-Penetrating Radar (GPR)

Capabilities of GPR

- Layer thicknesses
- Void location
- Stripping in asphalt layers
- Presence of moisture
- Detection/locate subsurface anomalies

GPR contributes to the structural assessment of pavements

- Predict pavement performance
- Determine upgrade requirements
- Prevent unforeseen pavement failures

GPR is nondestructive

- Quicker results
- Fewer delays and interference

ERDC GPR Applications

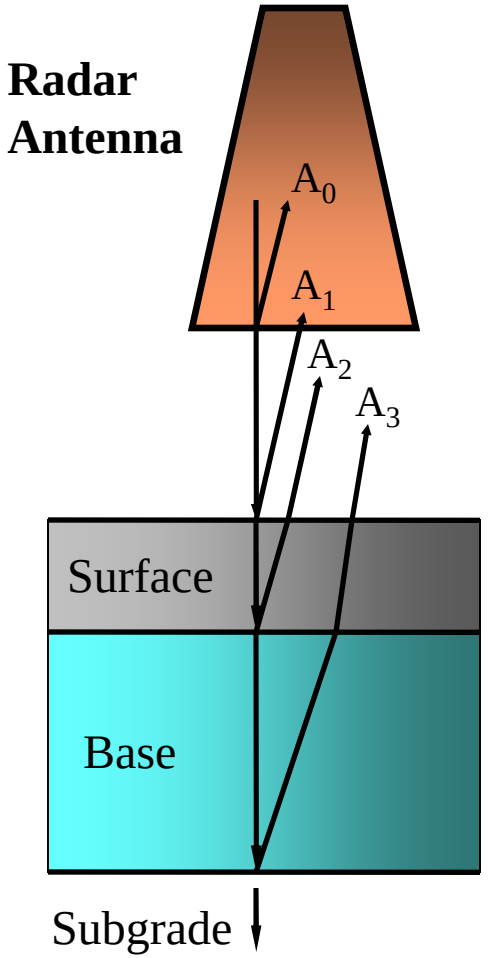
- **Airfield evaluations**
  - Current pavement condition
  - Layer thicknesses can be used with falling weight deflectometer (FWD) data to backcalculate layer moduli
- **Road structures**
  - Maintenance and repair
  - Future design
- **Test sections at ERDC**
  - Quality assurance tool

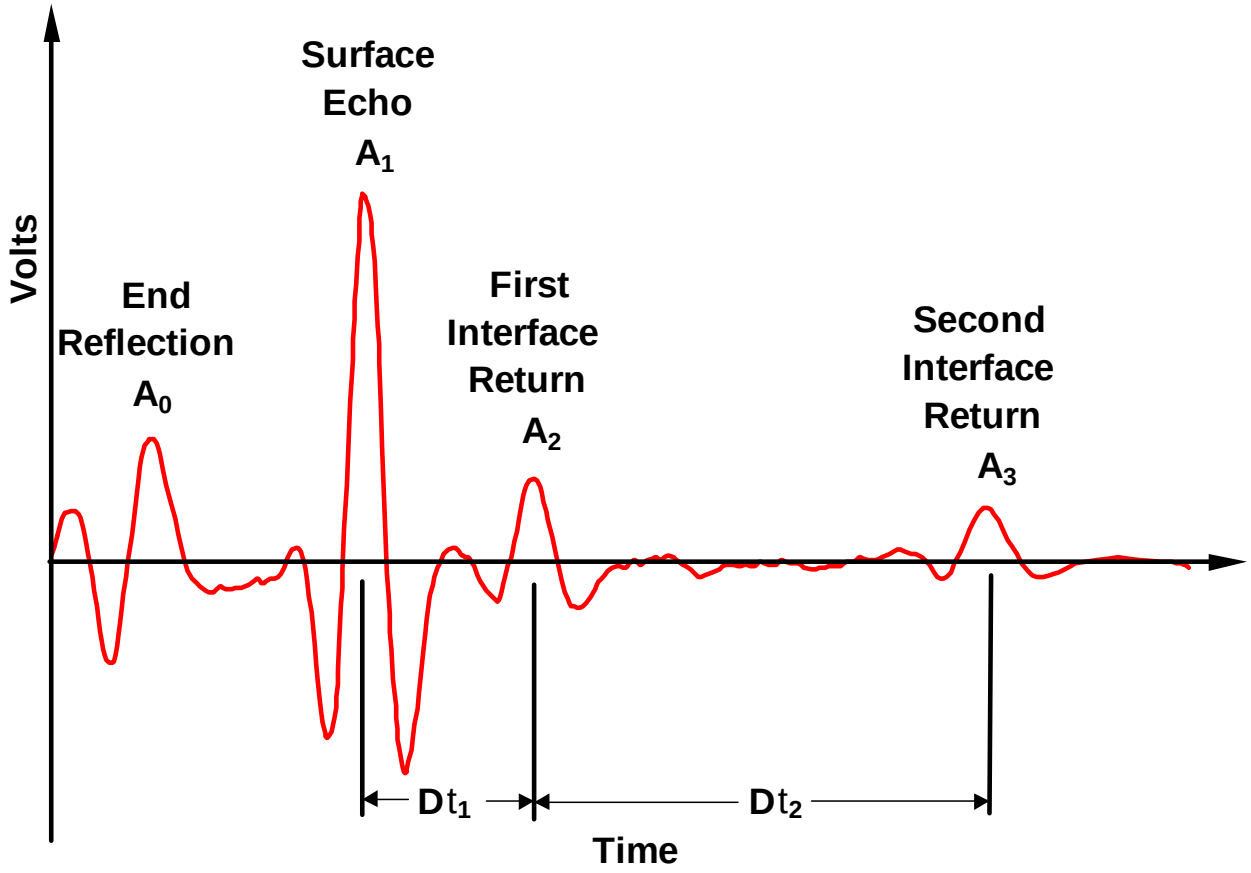
Pulse Radar System



- Developed under Small Business Innovative Research (SBIR) with Pulse Radar (Houston, TX)
- Multi-Antenna
  - 1 GHz (1 meter)
  - 500 MHz (2 meters)
  - 250 MHz (3 meters)
  - 100 MHz (5-10 meters)
- Operates at highway speeds

Short Pulse GPR





Note: Requires dielectric discontinuity at layer interfaces

GPR Equations

- Layer thickness*

$$h = \frac{c \times \Delta t}{2\sqrt{\varepsilon}}$$

h = layer thickness
c = speed of light
Δt = two way travel time
ε = dielectric

- Dielectric values*
  - Use assumed value (typically 6.0 for asphalt, 8.0 for concrete)
  - Backcalculate dielectric from core
  - Use equations

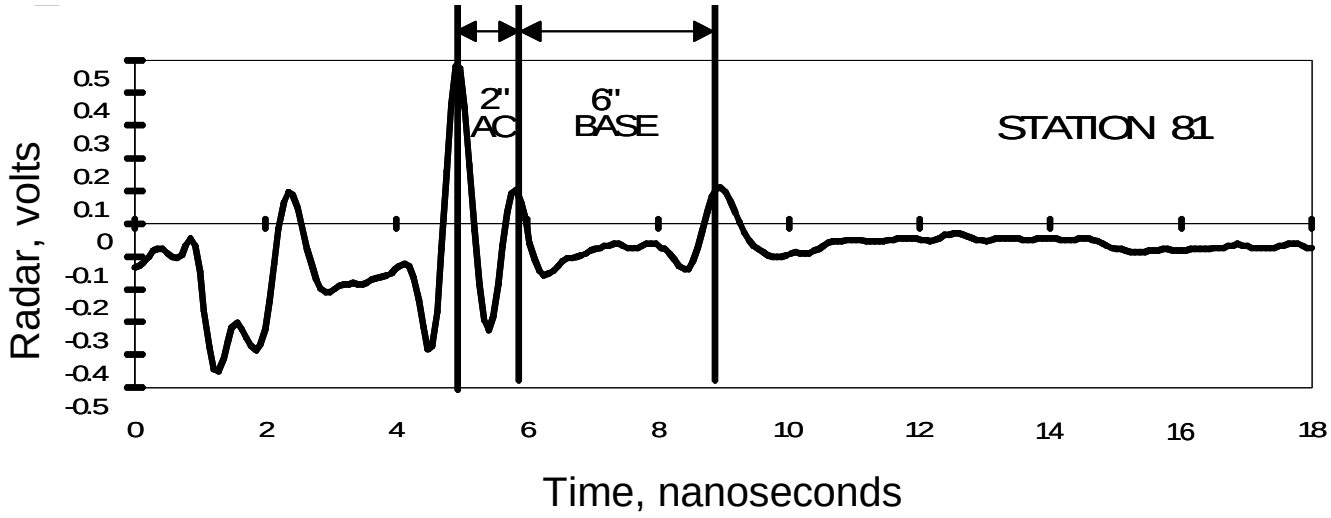
$$\varepsilon_a = \left[\frac{1+\frac{A_0}{A_m}}{1-\frac{A_0}{A_m}}\right]^2$$

$$\sqrt{\varepsilon_b} = \sqrt{\varepsilon_a}\left[\frac{1-\left[\frac{A_0}{A_m}\right]^2+\left[\frac{A_1}{A_m}\right]}{1-\left[\frac{A_0}{A_m}\right]^2-\left[\frac{A_1}{A_m}\right]}\right]$$

ε_a = dielectric of first layer
ε_b = dielectric of base layer
A_m = metal reflection amplitude
A_0 = surface reflection amplitude
A_1 = base reflection amplitude

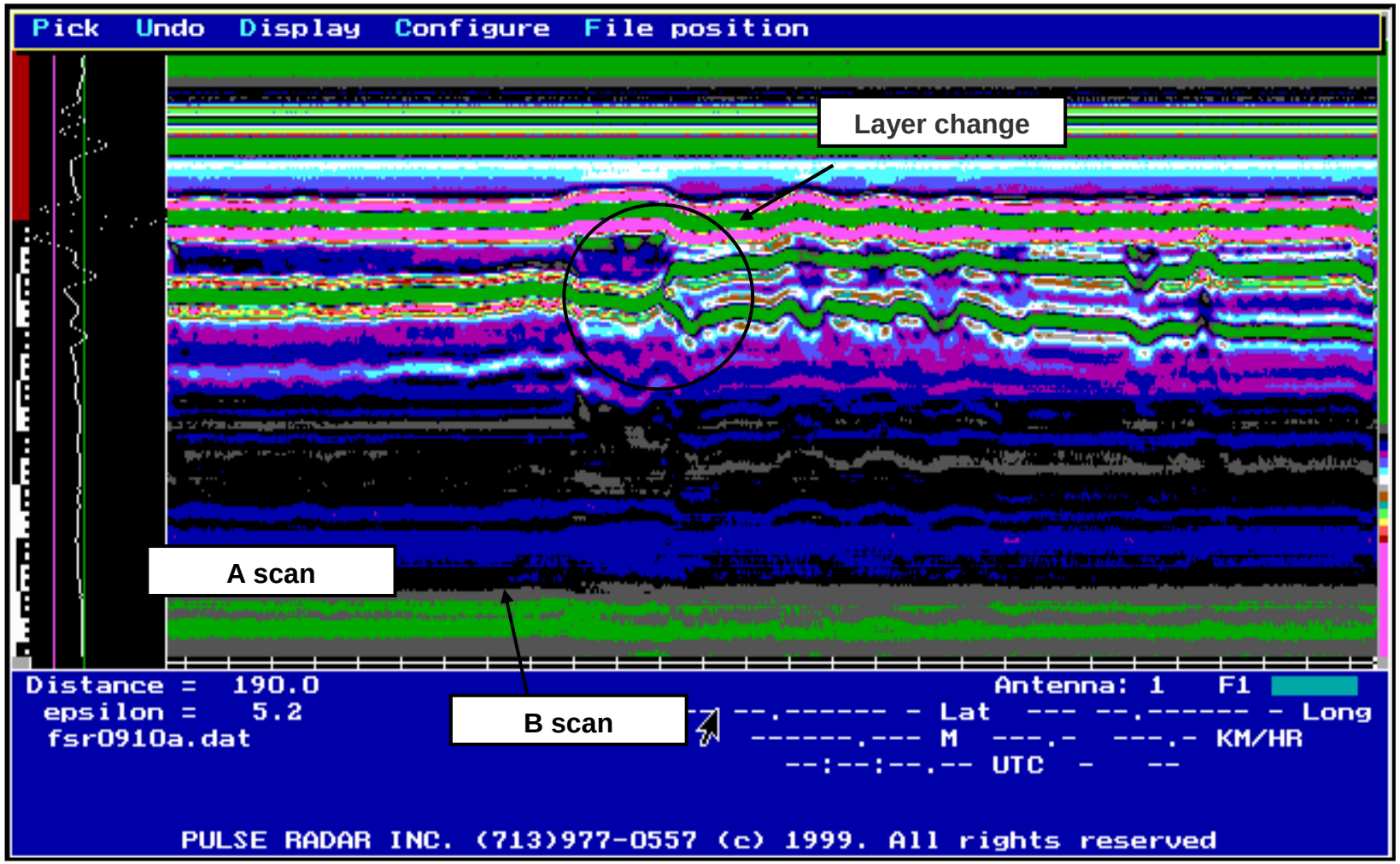
*Scullion et al, 1994

GPR Data Analysis

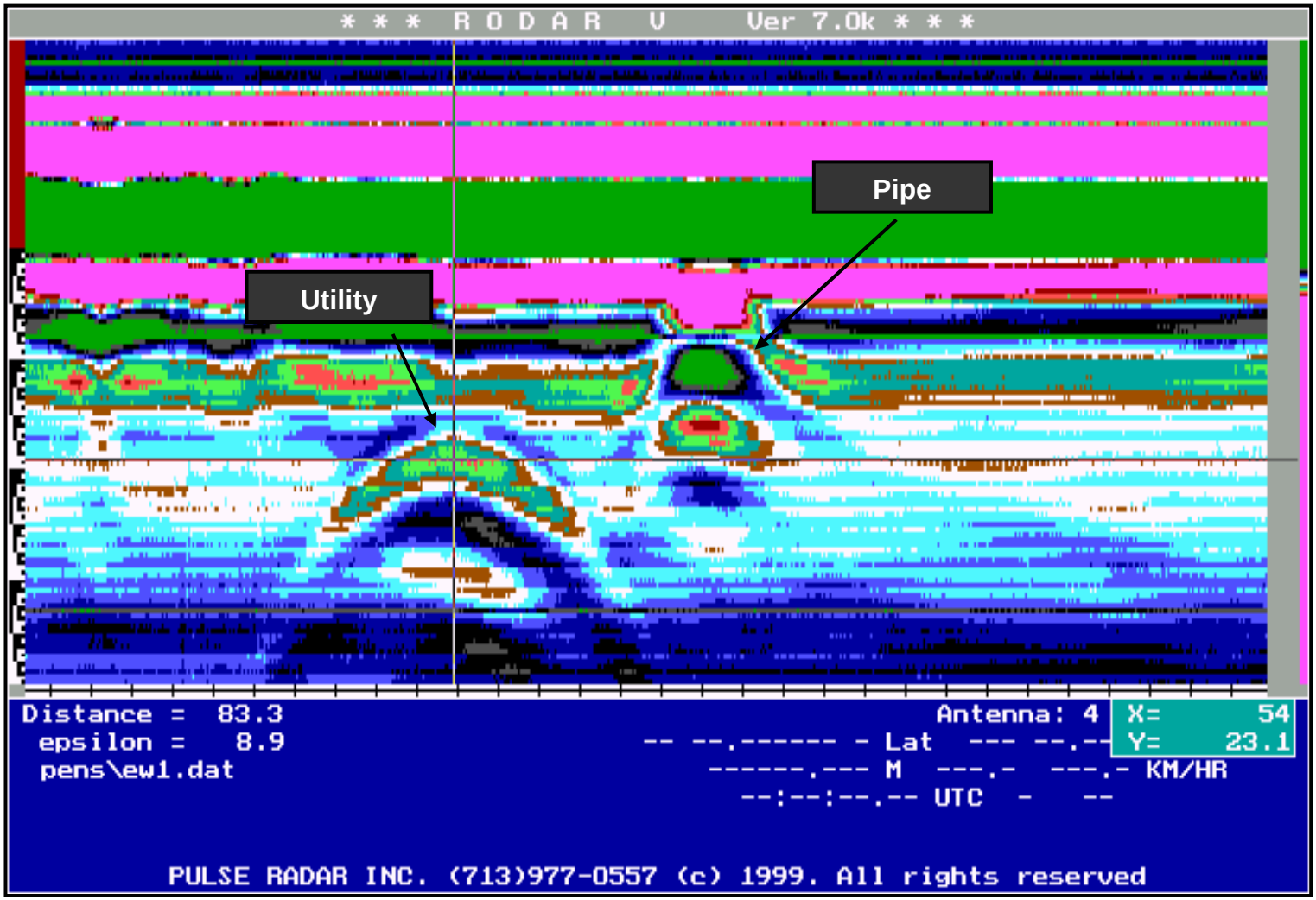


- Layer interfaces (signal peaks) are found using a cross-correlation technique
- Layer thickness are calculated using the locations of the signal peaks and the previous equations
- Layer thickness measurements improve when calibrated/corrected with a thickness value from a single core (“ground truth”)

GPR Display

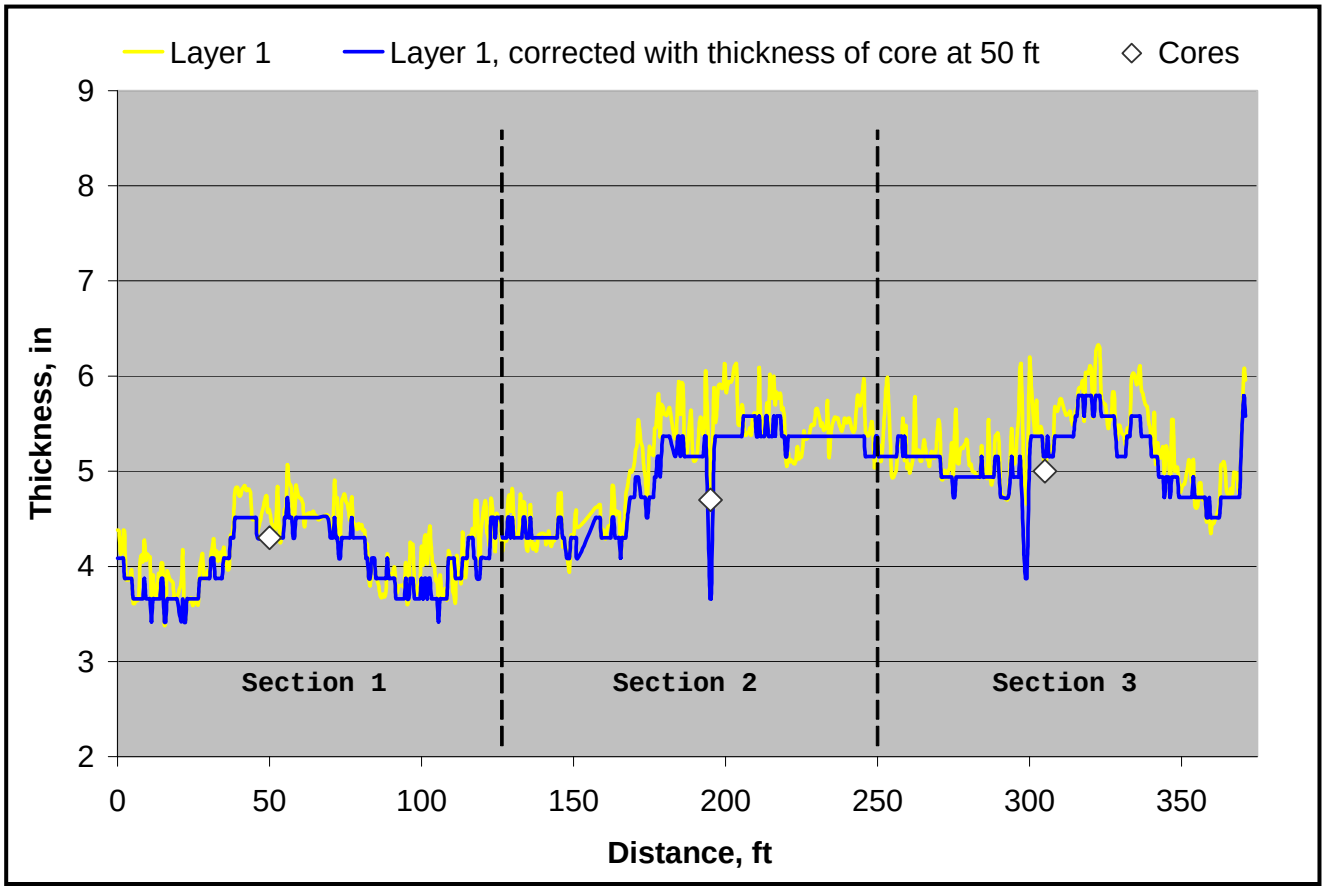

Pick Undo Display Configure File position
Layer change
A scan
B scan
Distance = 190.0
epsilon = 5.2
fsr0910a.dat
Antenna: 1 F1
--.------ - Lat --- --.------ - Long
------.--- M ---.- ---.- KM/HR
--:--:--.-- UTC - --
PULSE RADAR INC. (713)977-0557 (c) 1999. All rights reserved

Detection of Subsurface Utilities



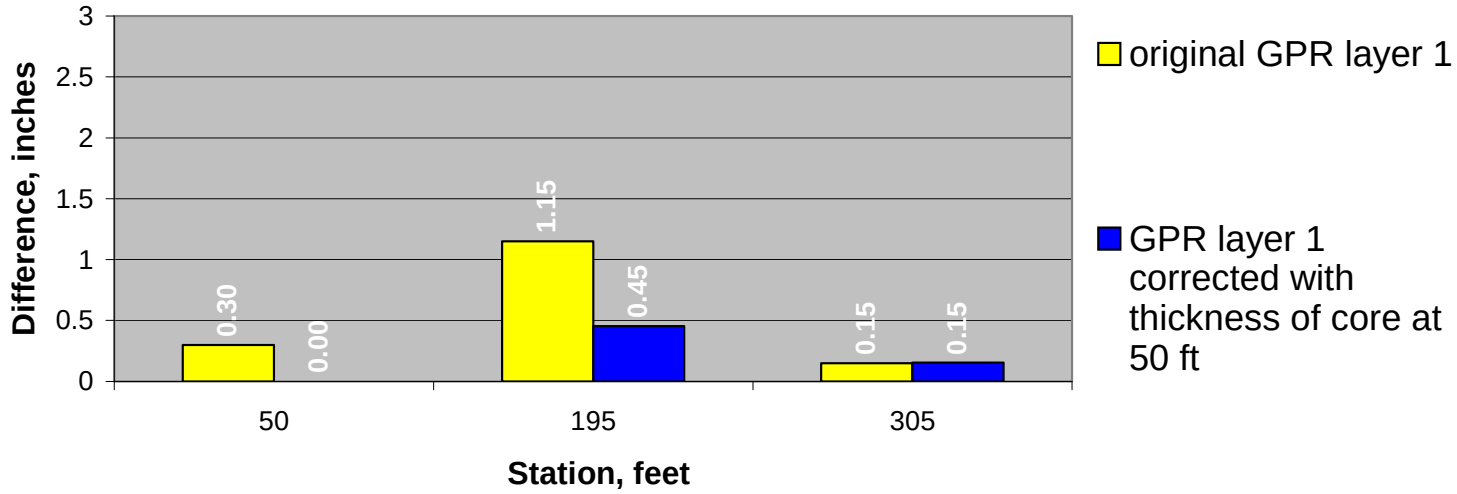
Verification – Flexible Pavements

Layer 1 original and corrected thicknesses as determined from the 1 GHz antenna on the ERDC asphalt test pavement

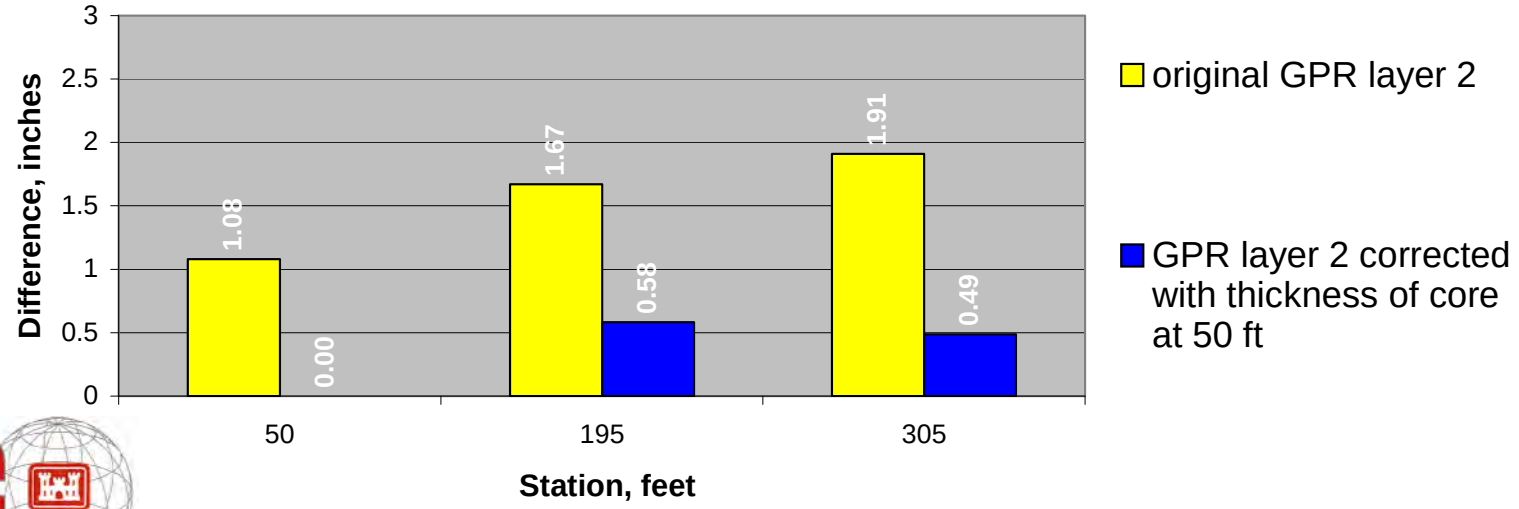


Differences/Errors

Asphalt test pavement – Asphalt, layer 1 (1 GHz)

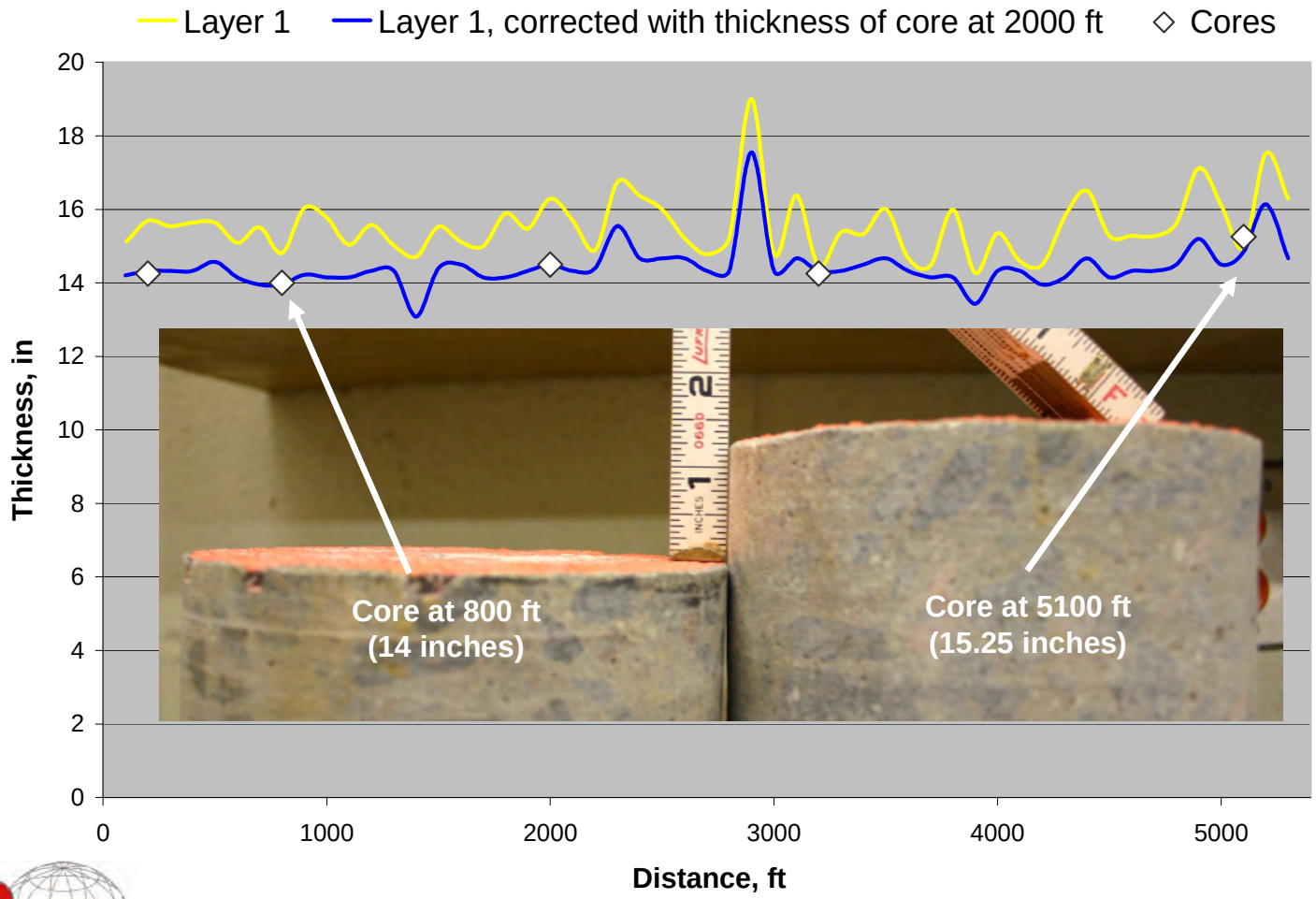


Asphalt test pavement – Base, layer 2 (1 GHz)



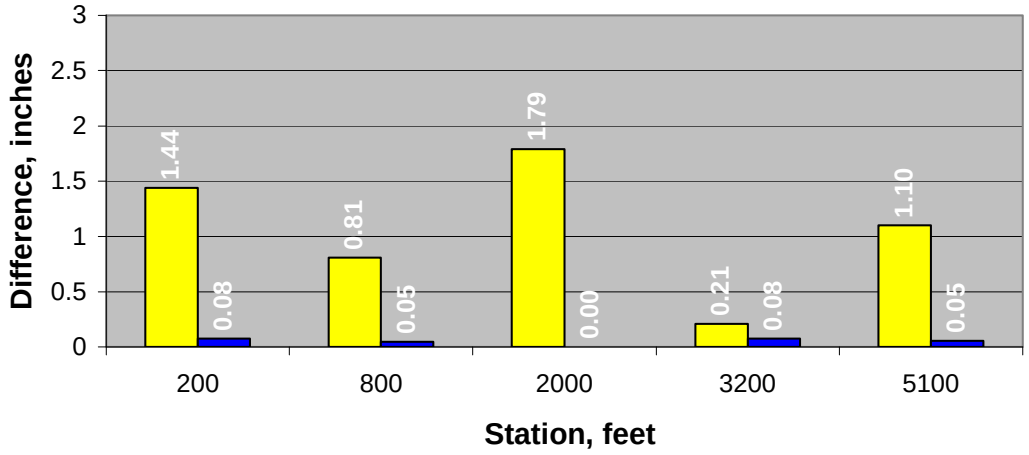
Verification – Rigid Pavement

Layer 1 original and corrected thicknesses as determined from the 1 GHz antenna on the Portland Cement Concrete (PCC) airfield pavement



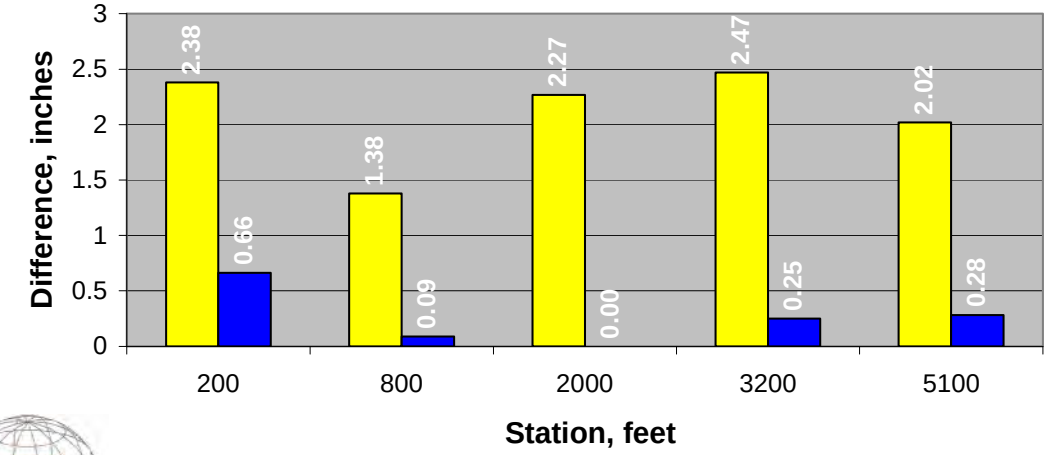
Differences/Errors

PCC airfield pavement – layer 1 (1 GHz)



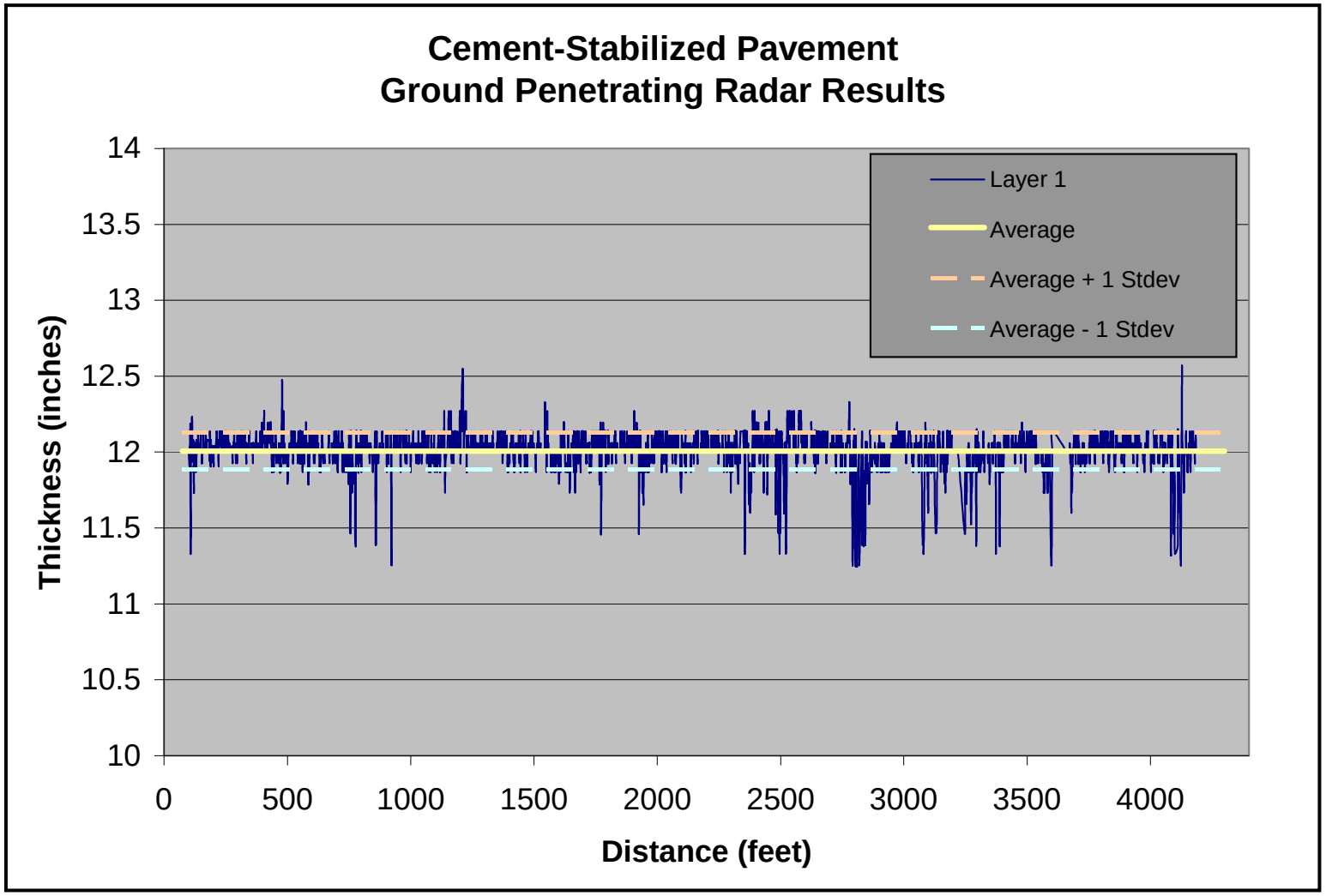
- original GPR layer 1 data
- GPR layer 1 data corrected with thickness of core at 2000 ft

PCC airfield pavement – layer 1 (500 MHz)



- original GPR layer 1 data
- GPR layer 1 data corrected with thickness of core at 2000 ft

Cement-Stabilized Soil



Summary and Conclusions

- Continuous thickness measurements along the entire length of the pavement ensures that changes in layer structure will be detected

- Combination of the 1GHz and 500 MHz antenna appears to provide both the resolution and penetration necessary for sampling most typical pavement structures

- At least one core is required to calibrate GPR thicknesses
  - Flexible pavement - error is reduced from an average of 1.04 inches to 0.42 inches
  - Rigid pavement – error is reduced from an average of 1.59 inches to 0.19 inches

Summary and Conclusions

- Measuring layer thicknesses with GPR has the potential to minimize time required for pavement evaluations by optimizing coring and DCP testing
- GPR is useful for detecting utilities
- Using layer thicknesses from GPR along with FWD data results in more accurate backcalculated moduli, and therefore, more reliable predictions of structural capacity

Questions?



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SEISMIC REMEDIATION OF THE CLEMSON UPPER AND LOWER DIVERSION DAMS; EVALUATION, CONCEPTUAL DESIGN AND DESIGN

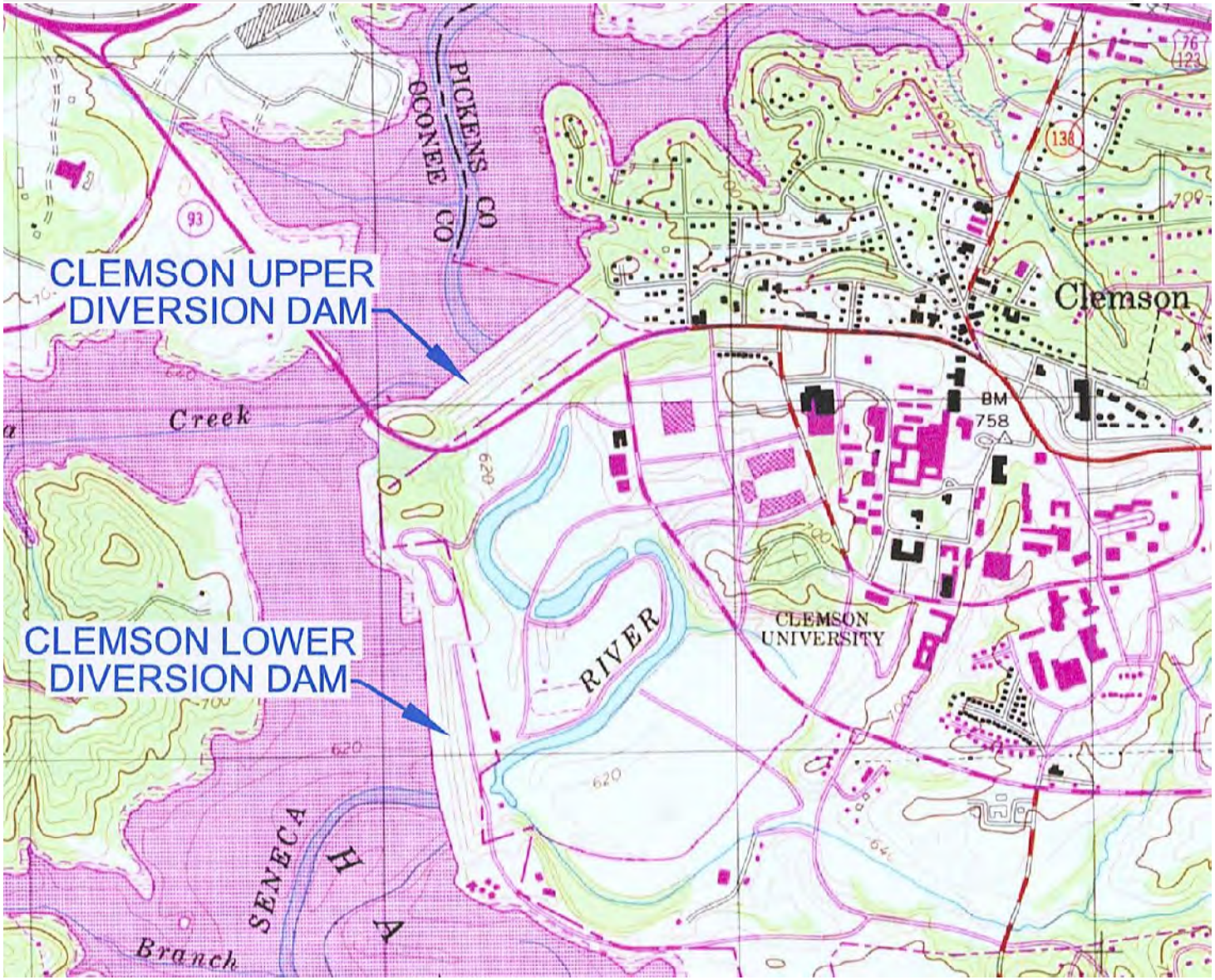
Lee Wooten, P.E.
GEI Consultants, Inc.
Winchester, MA

Ben Foreman
U.S. Army Corps of Engineers
Savannah District

Site Location: Clemson, SC

U.S. Army Corps of Engineers

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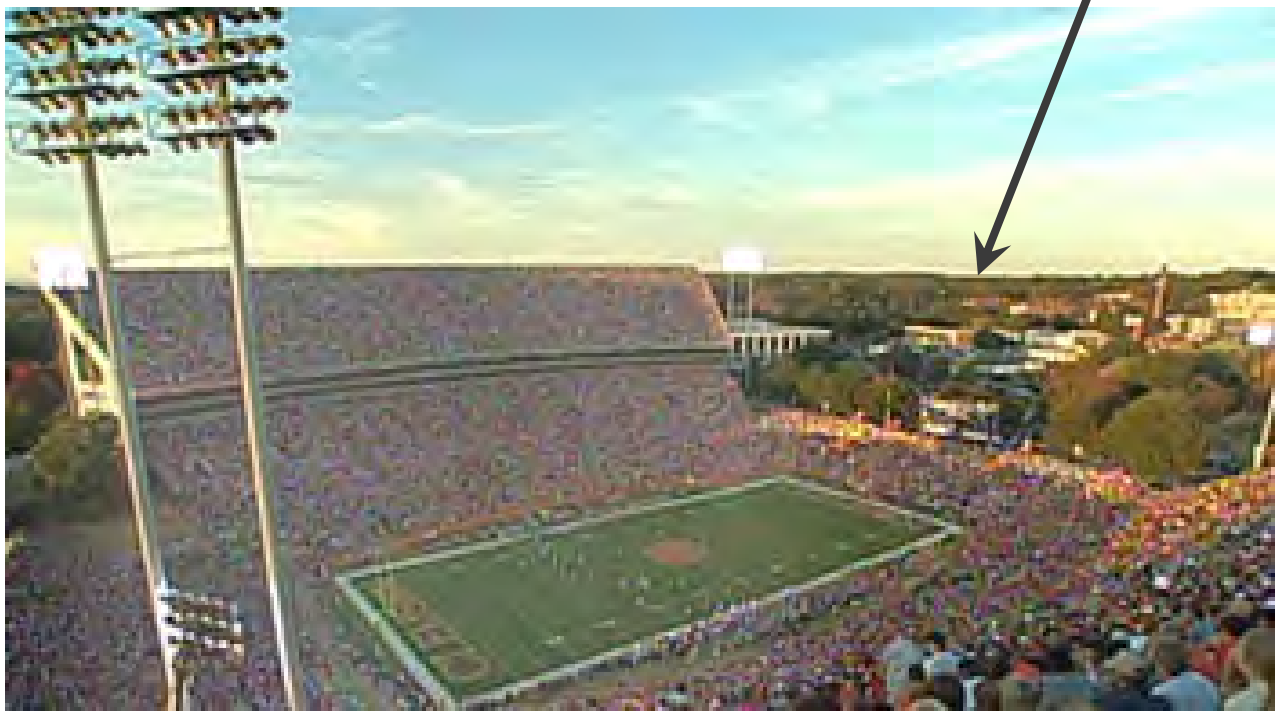


Site Location:
Death Valley (Clemson), SC

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Lower Dam & Lake Hartwell



Icon



Saint

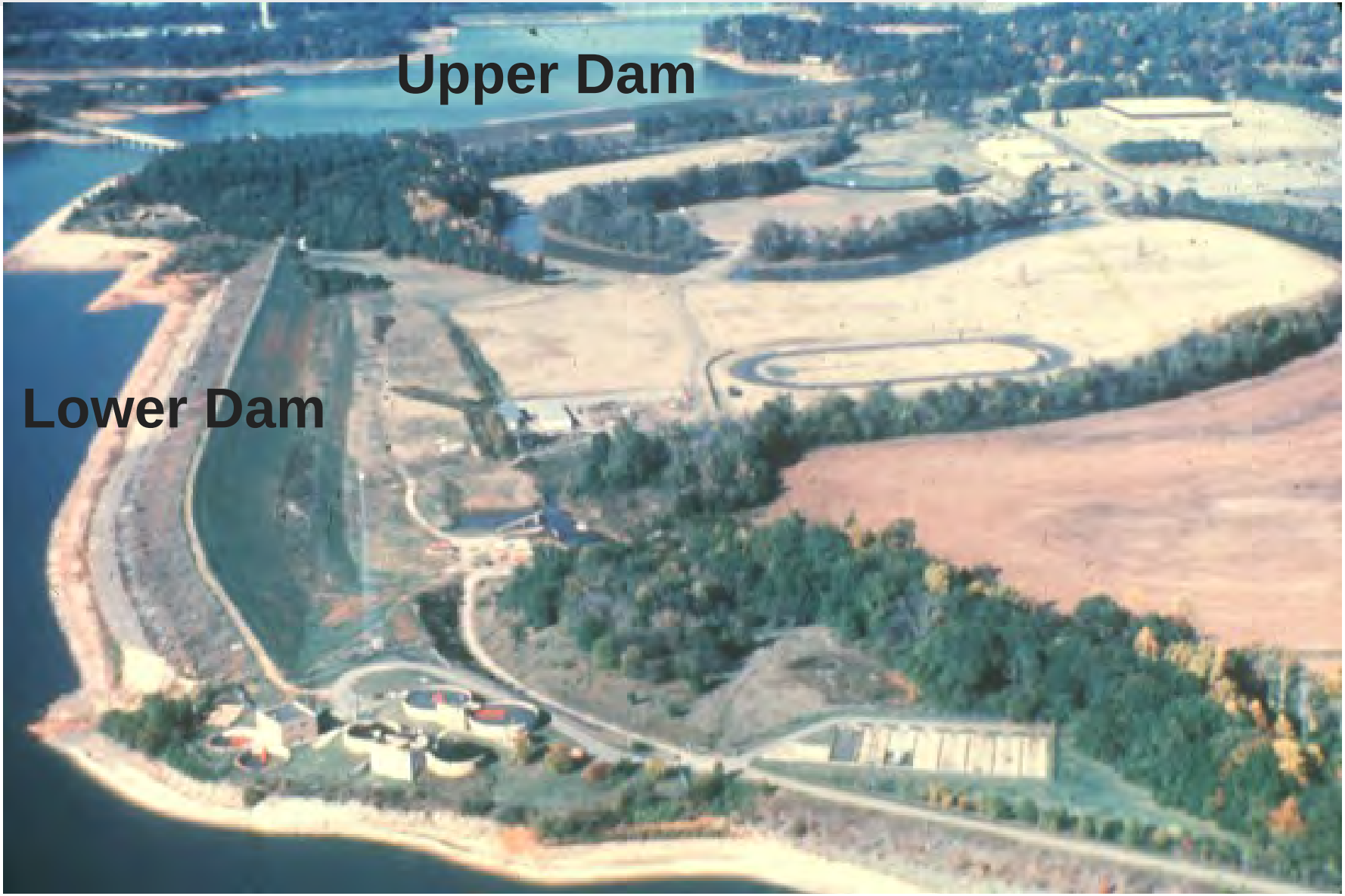


Clemson Saturday Religious Rituals

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Aerial View of the Dams



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Upper Diversion Dam



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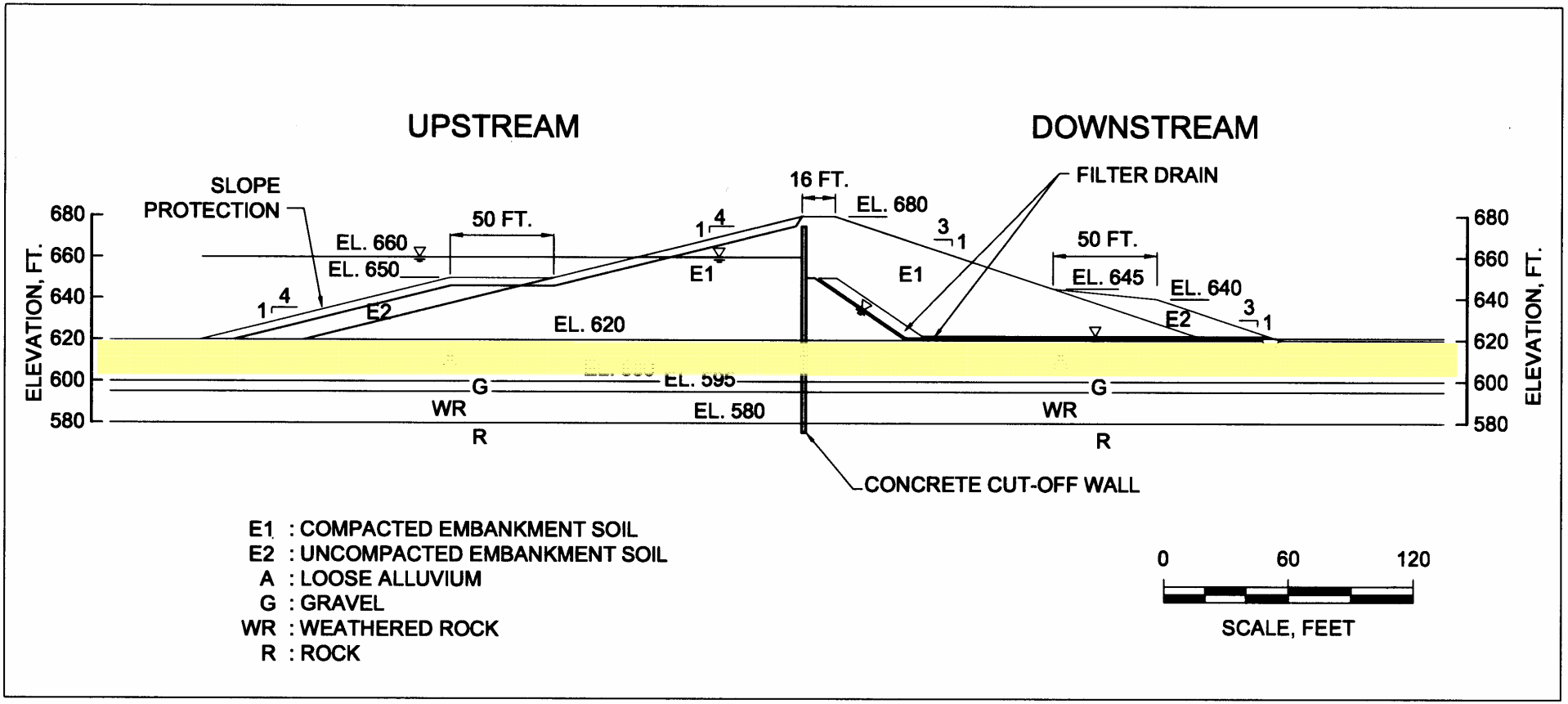
Lower Diversion Dam



Simplified Cross Section of Clemson Diversion Dams

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Installation of Cutoff Wall (1980s)

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Seepage Investigations

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Early 1980's seepage investigations

- Documented loose silty sand / sandy silt layer within the foundation alluvium
  - Thickness from 7 to 28 feet
  - N-values = 3 to 30 blows per foot
- Reconnaissance report submitted to HQUSACE in 1986 recommending additional seismic stability investigations

Late 1980's and Early 1990's Data Collection & MCE Determination

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Data Collection

- 16 SPT borings
- 23 borings with undisturbed tube samples
- 15 CIUC (R') triaxial tests to large strains
- Laboratory vane shear, large strains
- Cross-hole seismic surveys (Vs profiles)

MCE Determination (WES)

- MCE: far field event with MM=VII in SC Seismic Zone (includes Charleston)
- a_{max} = 0.19 g
- Four EQ records, including 1971 San Fernando records

Conditions for Liquefaction Slope Failure

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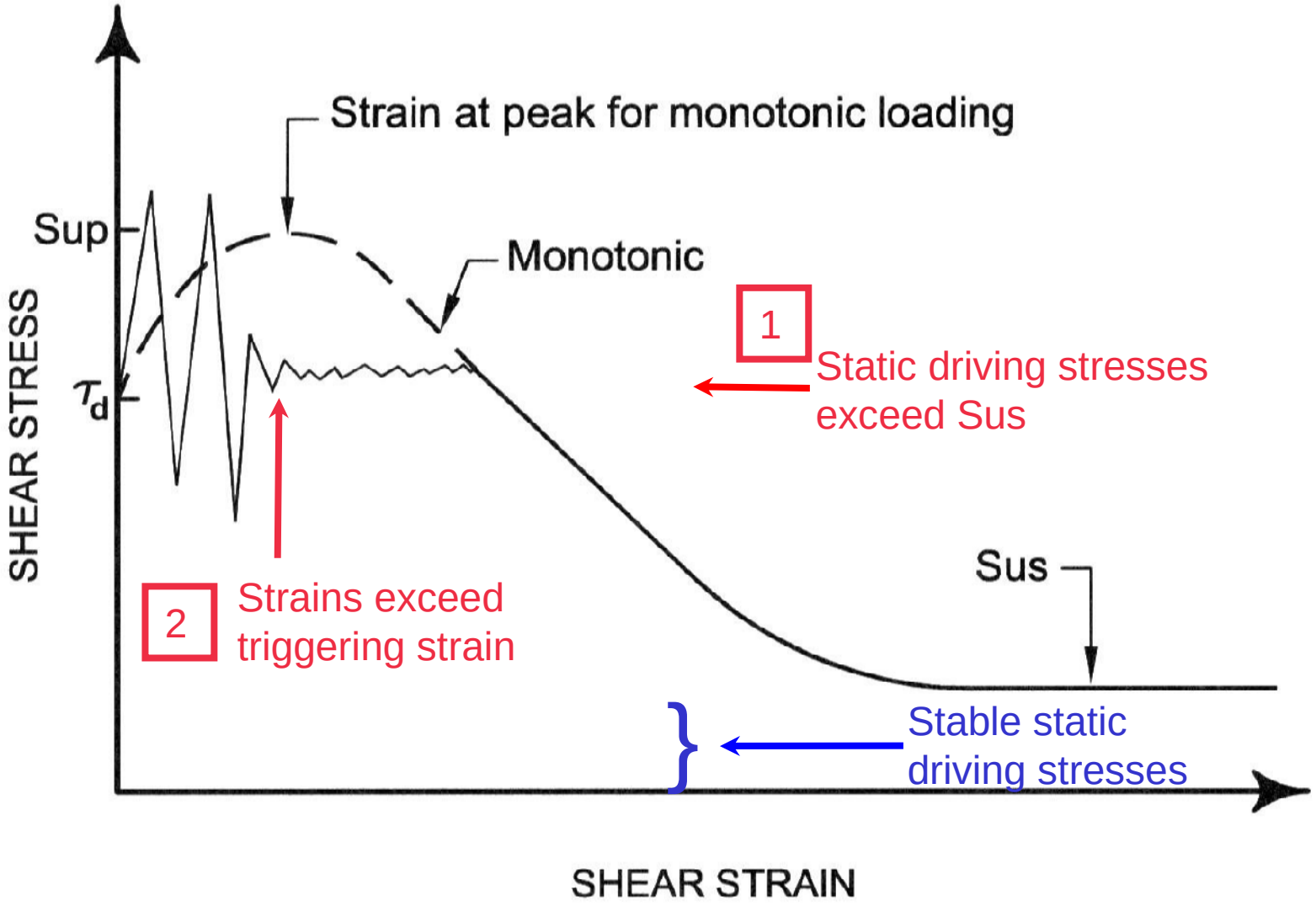
Two Conditions for Occurrence of a Liquefaction Slope Failure

- **Potentially Unstable -** Slope must be unstable if soil strengths drop to Sus (Undrained Steady State Strength)
- **Triggering Strains Occurrence -** Soils must undergo strains that exceed triggering strains

Liquefaction Slope Failure Conditions

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Seismic Stability Analyses for Clemson – 3 Levels

U.S. Army Corps of Engineers

GEI Consultants

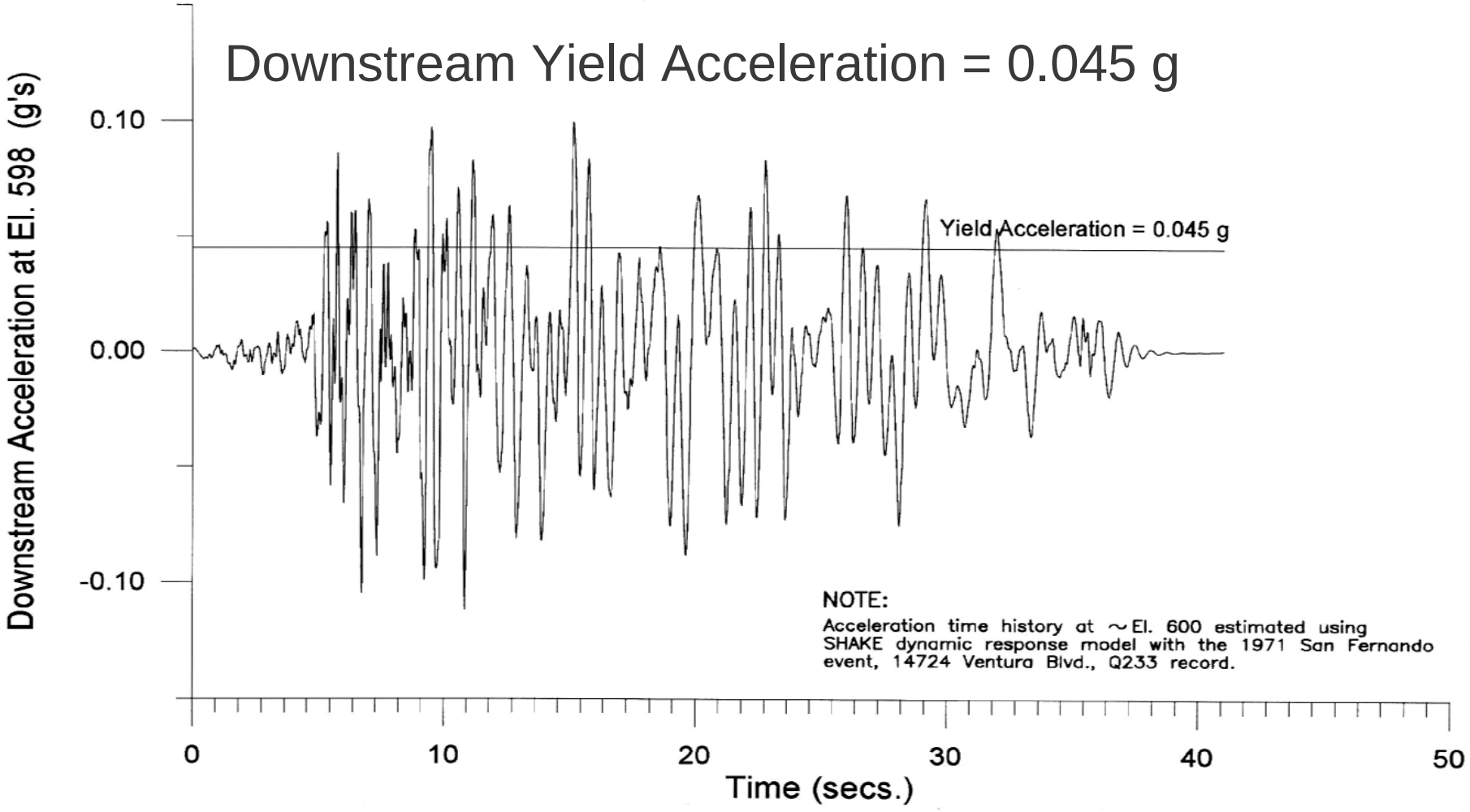
1. Steady-state-strength slope stability
2. One-dimensional triggering analysis; Newmark/SHAKE analysis beneath mid-slope berms
3. Two-dimensional dynamic finite element (FE) seismic model TARA, developed and applied by Prof. Liam Finn, UBC / Kagawa U.

1-D Triggering Analysis – Seismic Model

U.S. Army Corps of Engineers

GEI Consultants

Downstream Slope – SHAKE Time History of Stress

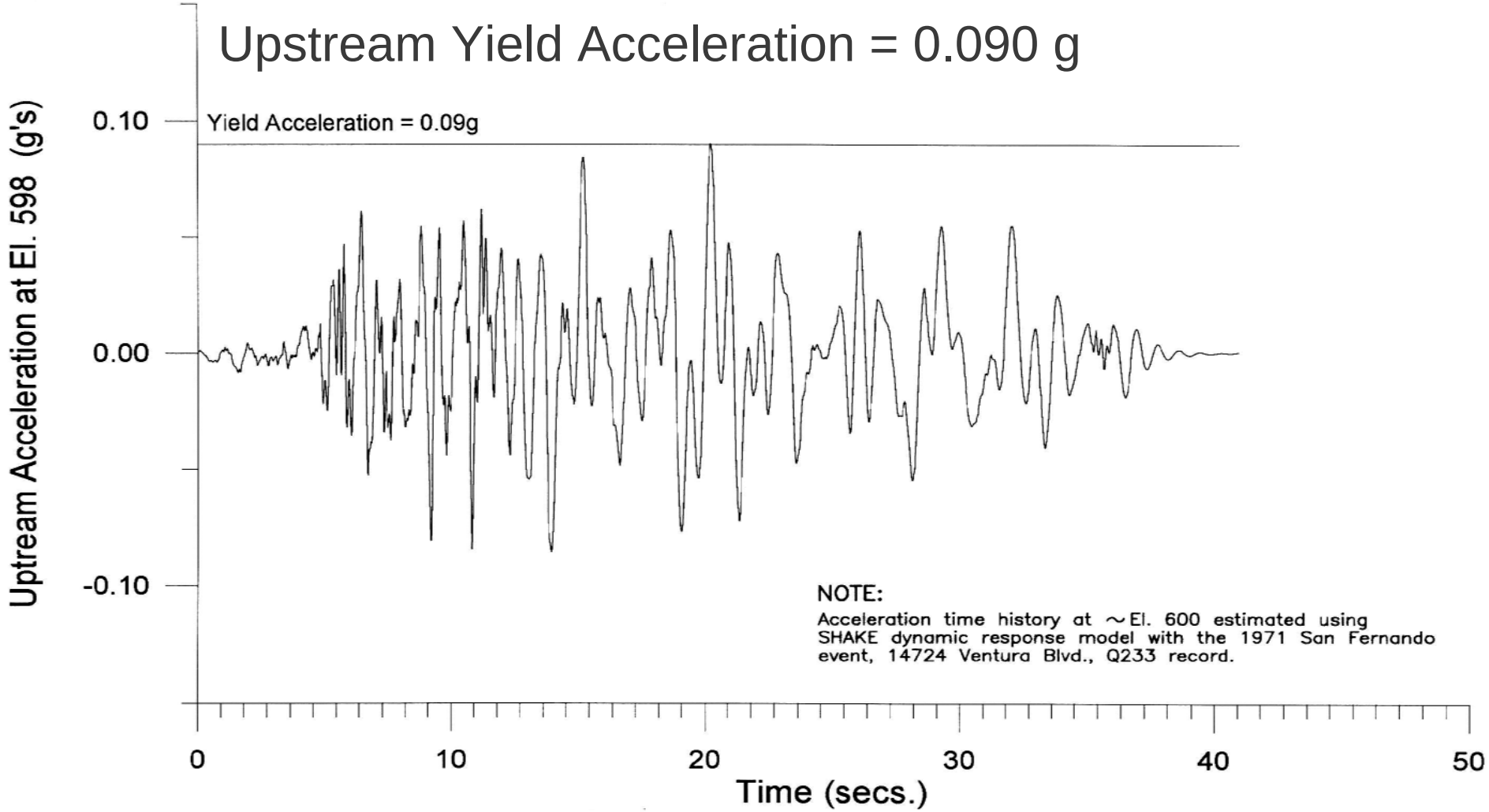


1-D Triggering Analysis – Seismic Model

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Upstream Slope – SHAKE Time History of Stress

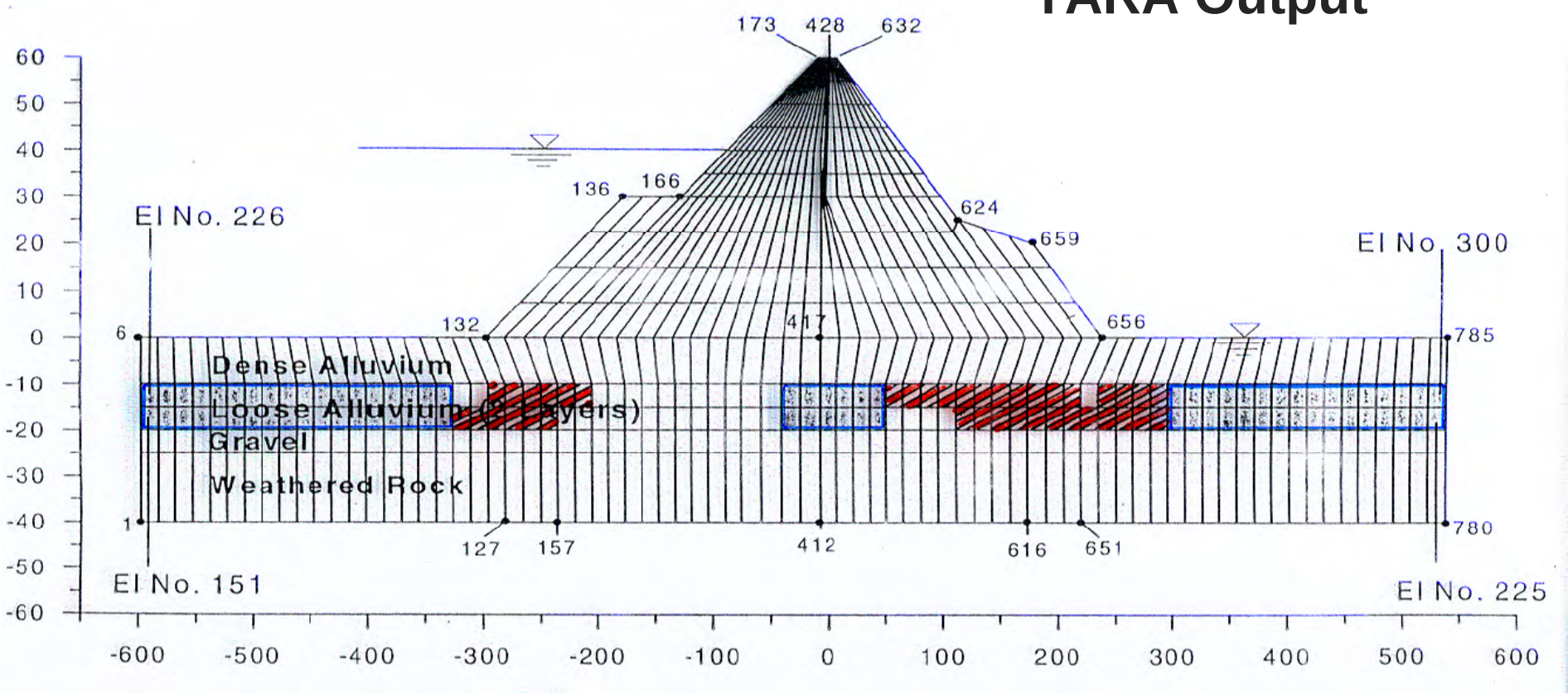


2-D Dynamic FE Analysis – Seismic Strains FE Model

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TARA Output

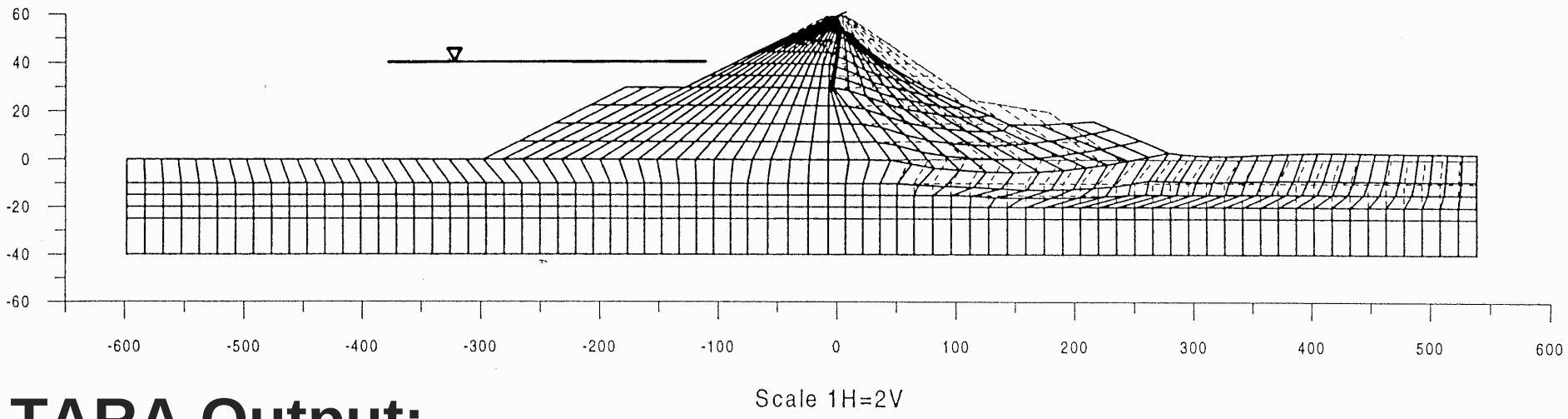


Triggered elements in red ($\gamma_{total} > 0.5\%$)

2-D Dynamic FE Analysis – Deformations FE Model

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TARA Output:

Horizontal Deformations:

- Crest - **3.4 feet**
- Downstream Berm - **37.6 feet**
- Upstream Berm - **0.3 feet**

Vertical Deformations:

- Crest – **7.4 feet**

Stability Evaluation Conclusions

U.S. Army Corps of Engineers

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Analyses using SHAKE/Newmark methods and TARA FE model indicate:

- **Downstream slope** will be **unstable** following MCE
- **Upstream slope** will be **stable** following MCE
- Dams would no longer be able to retain the normal reservoir
- Remediation of the downstream section of the dam is required
- No need to remediate the upstream section of the dam

Remedial Design

U.S. Army Corps of Engineers

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Goal:

Prevent a liquefaction failure and excessive deformations of the downstream sections of the Upper and Lower Clemson Diversion Dams during or following the Maximum Credible Earthquake (peak acceleration of 0.19 g)

Conceptual Designs

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GEI Consultants

1) Jet Grouting

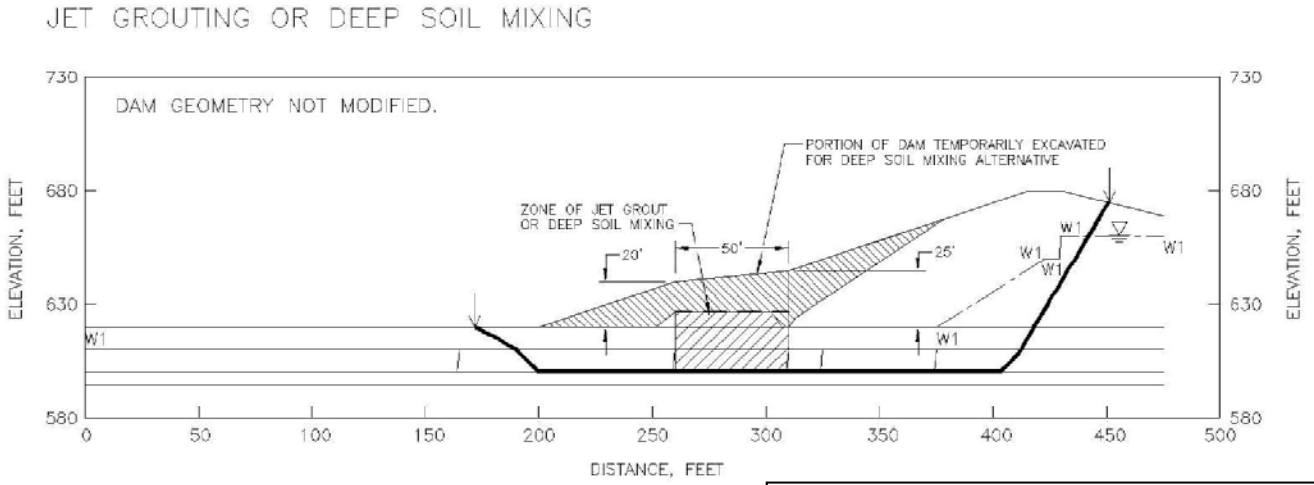
2) Deep Soil Mixing

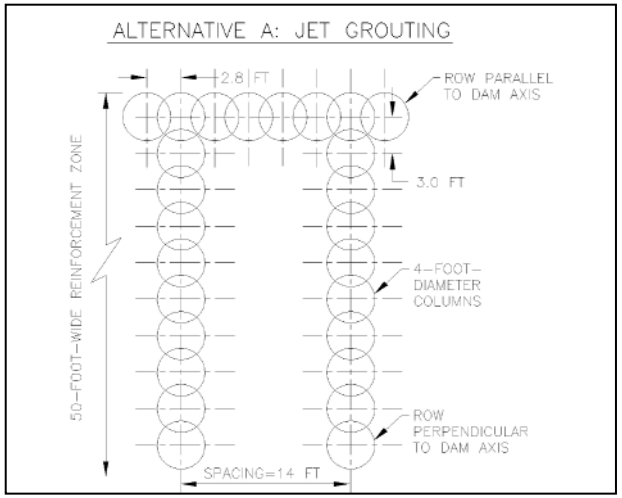
3) Stone Columns

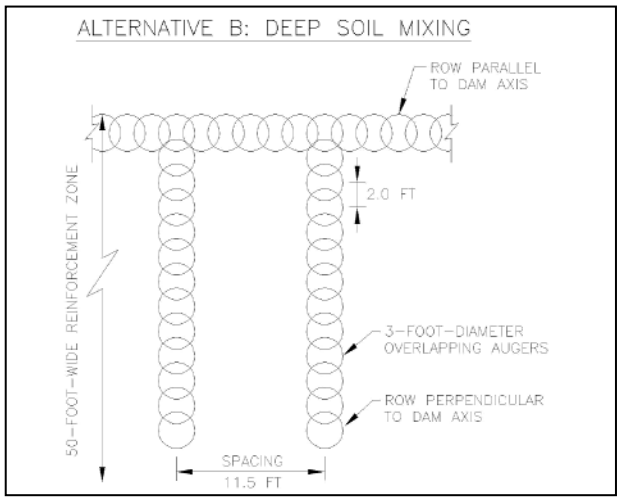
4) Excavation and Replacement

Conceptual Designs

1) Jet Grouting or 2) Deep-Soil Mixing





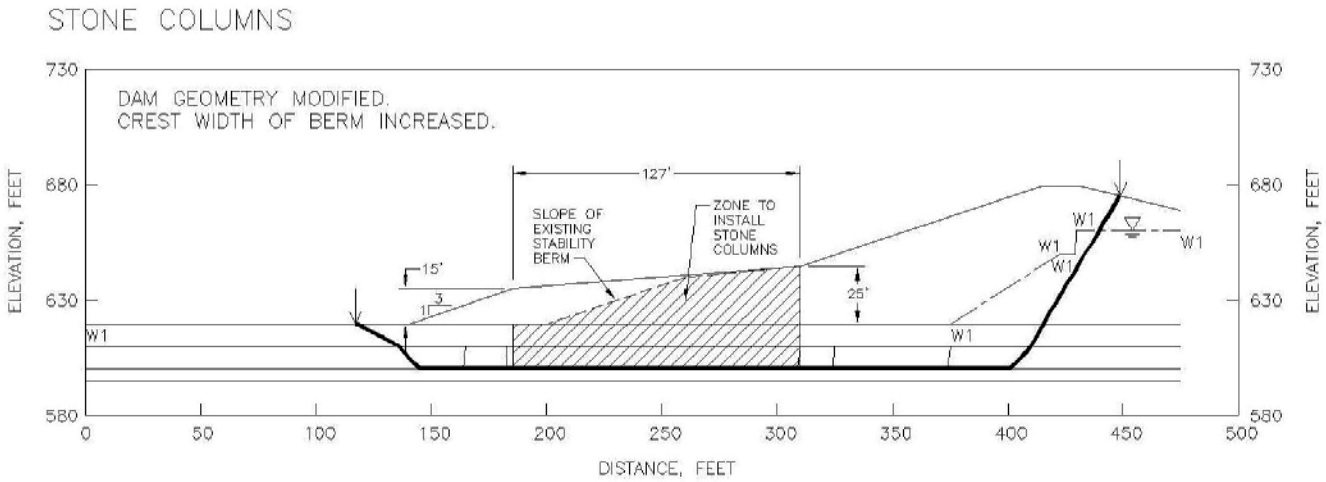


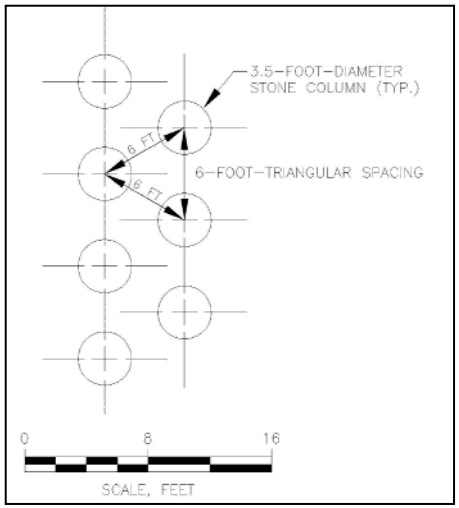
Conceptual Designs

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3) Stone Columns



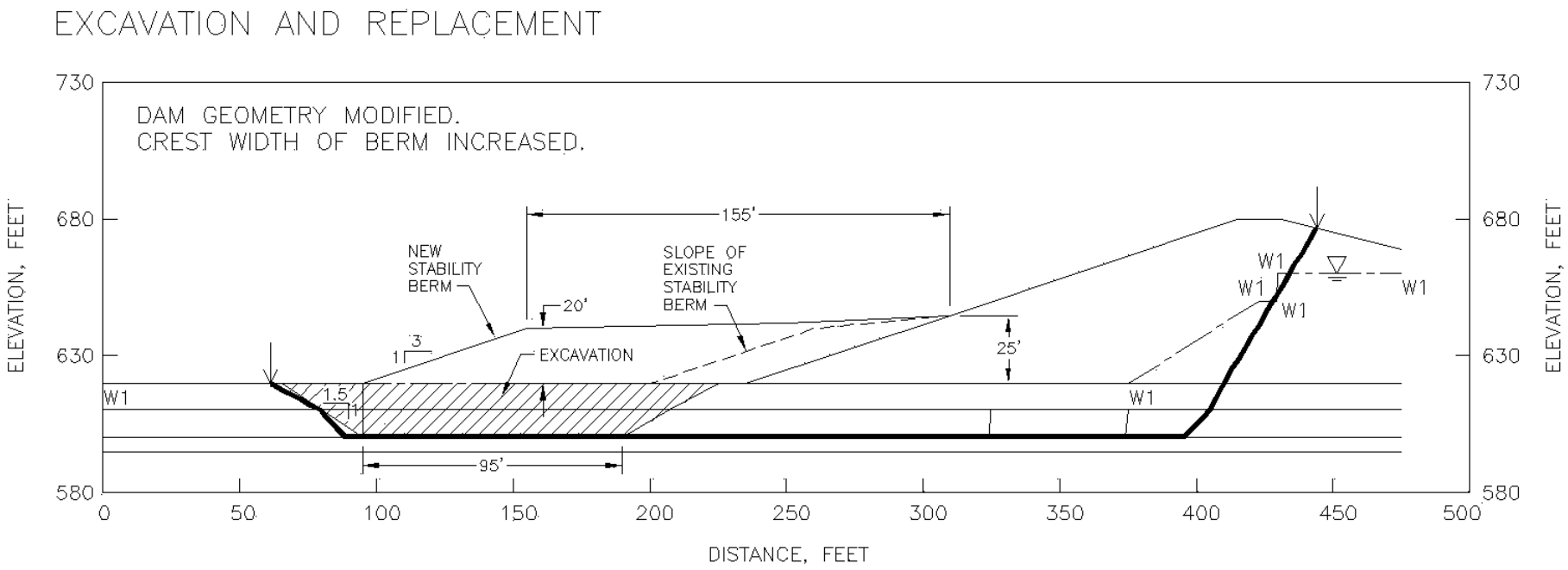


Conceptual Designs

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4) Excavation and Replacement



Conceptual Designs

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Option	Estimated Cost
Jet Grouting	$10,700,000 to $14,100,000
Deep Soil Mixing	$8,200,000 to $9,800,000
Stone Columns	$14,200,000 to $14,700,000
Excavation and Replacement	$9,800,000 to $10,900,000

Conceptual Designs

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DESIGN SELECTION

Criteria:

- Cost
- Quality Assurance
- Confidence in Model
- Stability during construction
- Construction traffic
- Impact on adjacent structures
- Potential for weather delays
- Aesthetics

Selection:

Deep Soil Mixing

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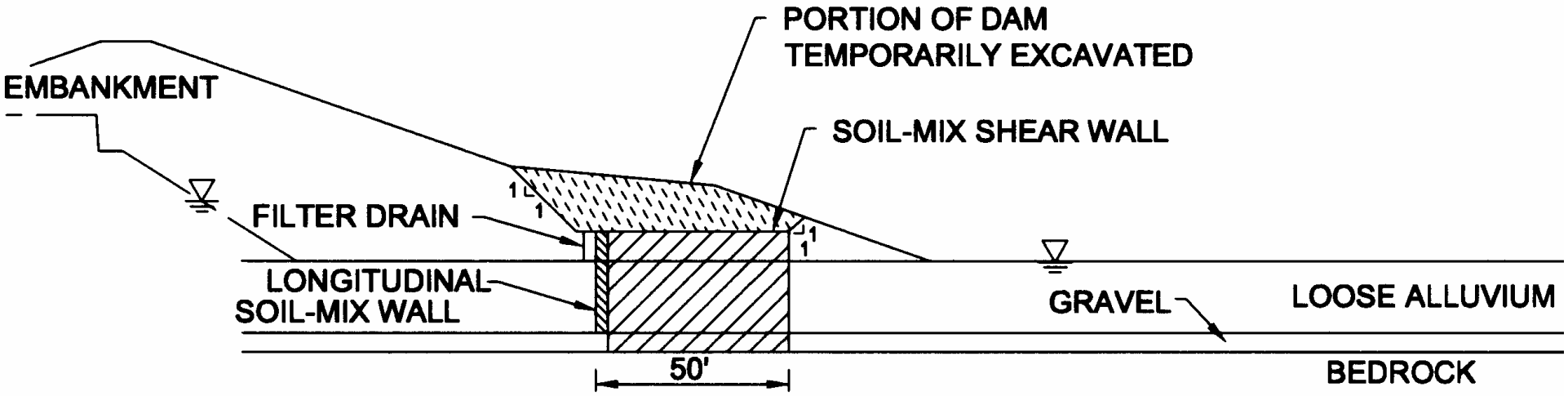
Final Design Details for Deep Soil Mix Remedial Measures

- 50-foot-long, 3-foot-wide transverse shear walls
- 15.5-foot wall spacing (center to center)
- Average shear strength of remediated zone = 2750 psf
- Soil-cement mix target strength ≈ 400 psi
- Wall embedments into upper berm material and into lower sand & gravel
- Longitudinal wall upstream of transverse walls
- Filtered drain upstream of longitudinal wall

Remedial Design

U.S. Army Corps of Engineers

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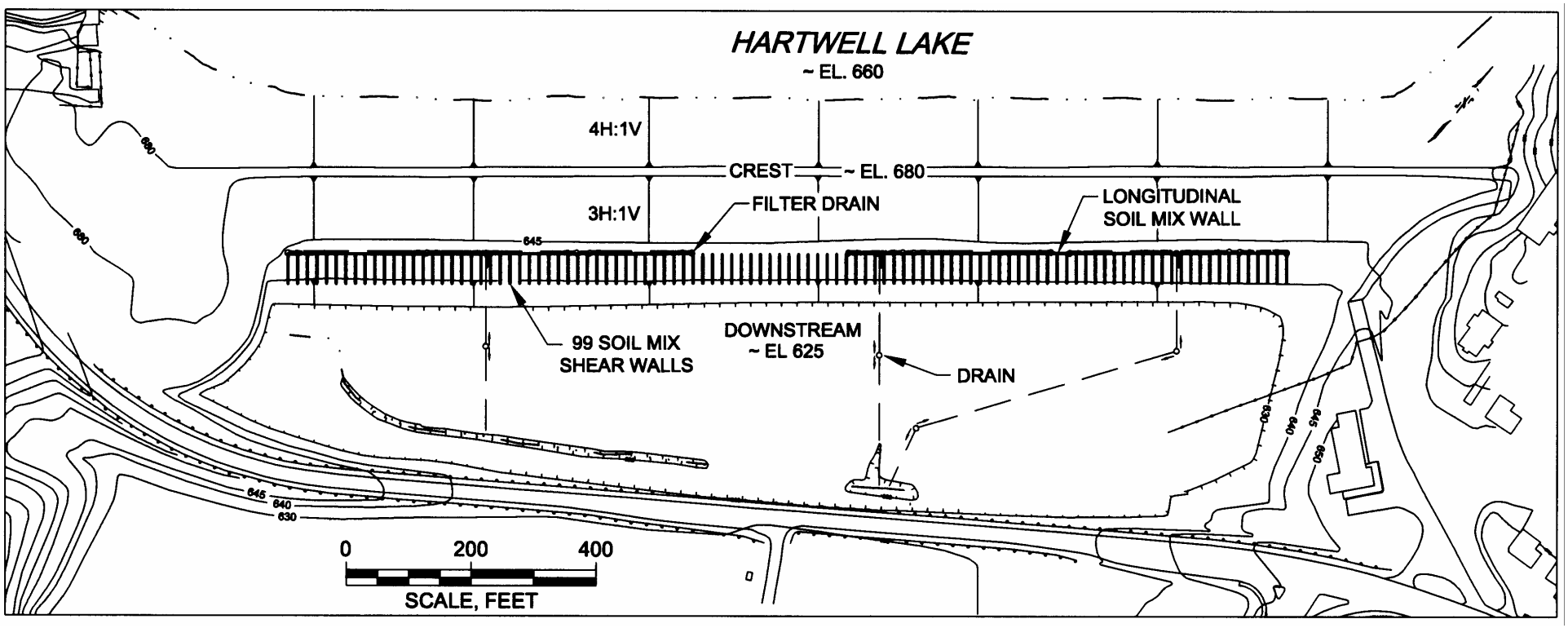


Final Design – Schematic Section

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Remedial Design



Final Design – Layout of Soil Mix Shear Walls Upper Diversion Dam

Remedial Design – Final Design Issues

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- What are the **Subsurface Conditions**?
  - Extent of Alluvium (top and bottom elevations)
  - Alluvium Soil Characteristics
  - Undrained Strength of Alluvium Clays & Silts for Excavation Stability
- What **soil cement shear strength** do we need?
- Can the Contractor produce a suitable **soil cement** with the Alluvium soils?
- **Where** should the soil mix walls be located to:
  - Provide seismic stability?
  - Minimize construction difficulties & costs?
- How should the design provide for **drainage of seepage**?
- How can we assure soil cement quality (**QA**)?

Remedial Design – Field Investigation

U.S. Army Corps of Engineers

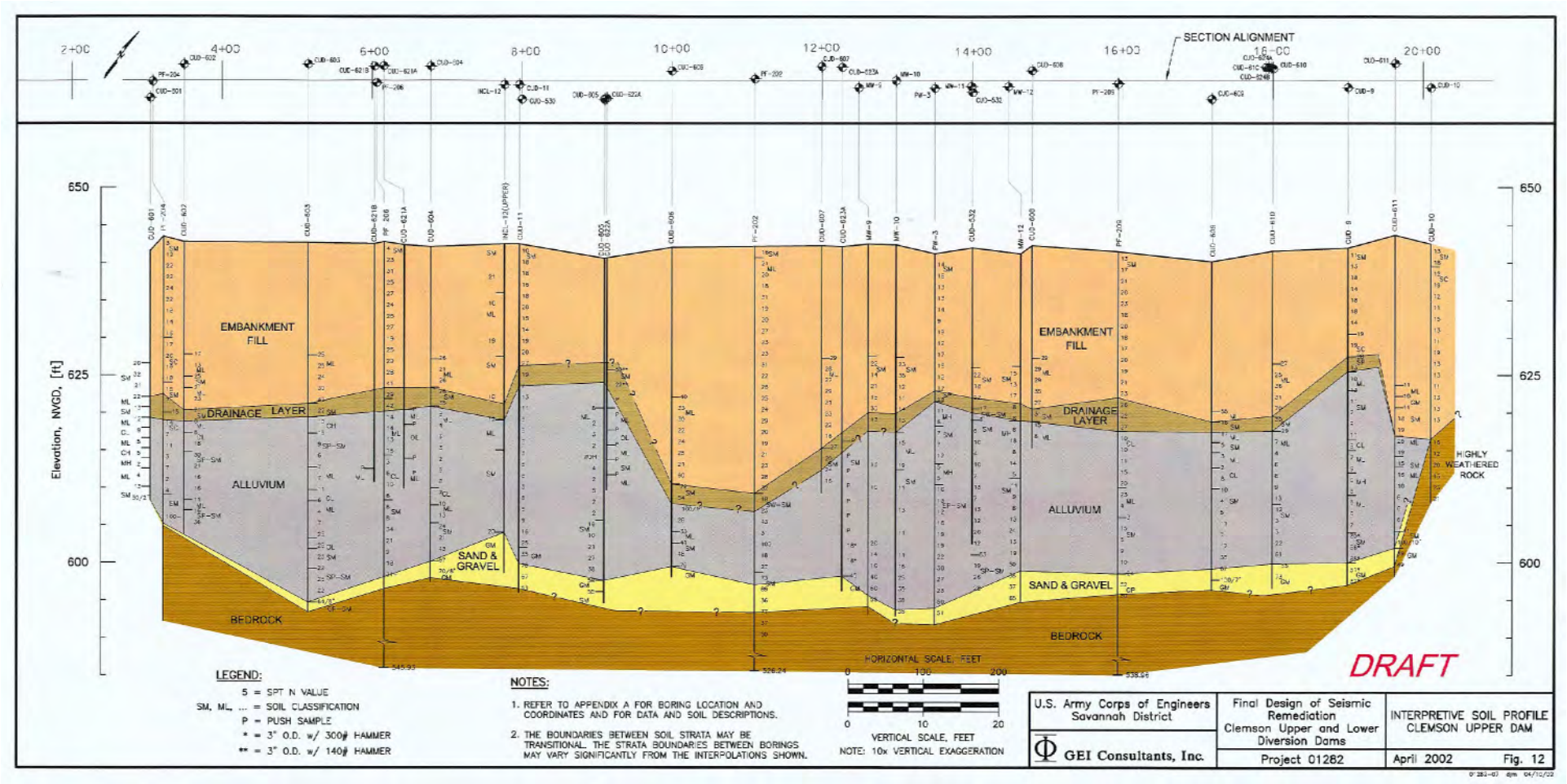
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- **Phase I Soil Borings (23)**
  - Thickness and depth of the alluvial layers requiring remediation
  - Characteristics of the alluvial layers
  - Thickness and depth of the blanket drain layer
  - Depth of the underlying dense sand, sand and gravel, or bedrock
- **Phase II Soil Borings (15)**
  - Bulk samples for soil-cement mix testing
  - Undisturbed samples of clay & silt alluvial soils for undrained strength testing
- **Groundwater Sampling (**for chloride & sulfate levels**)**
- **Local Cement Sampling**

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Remedial Design

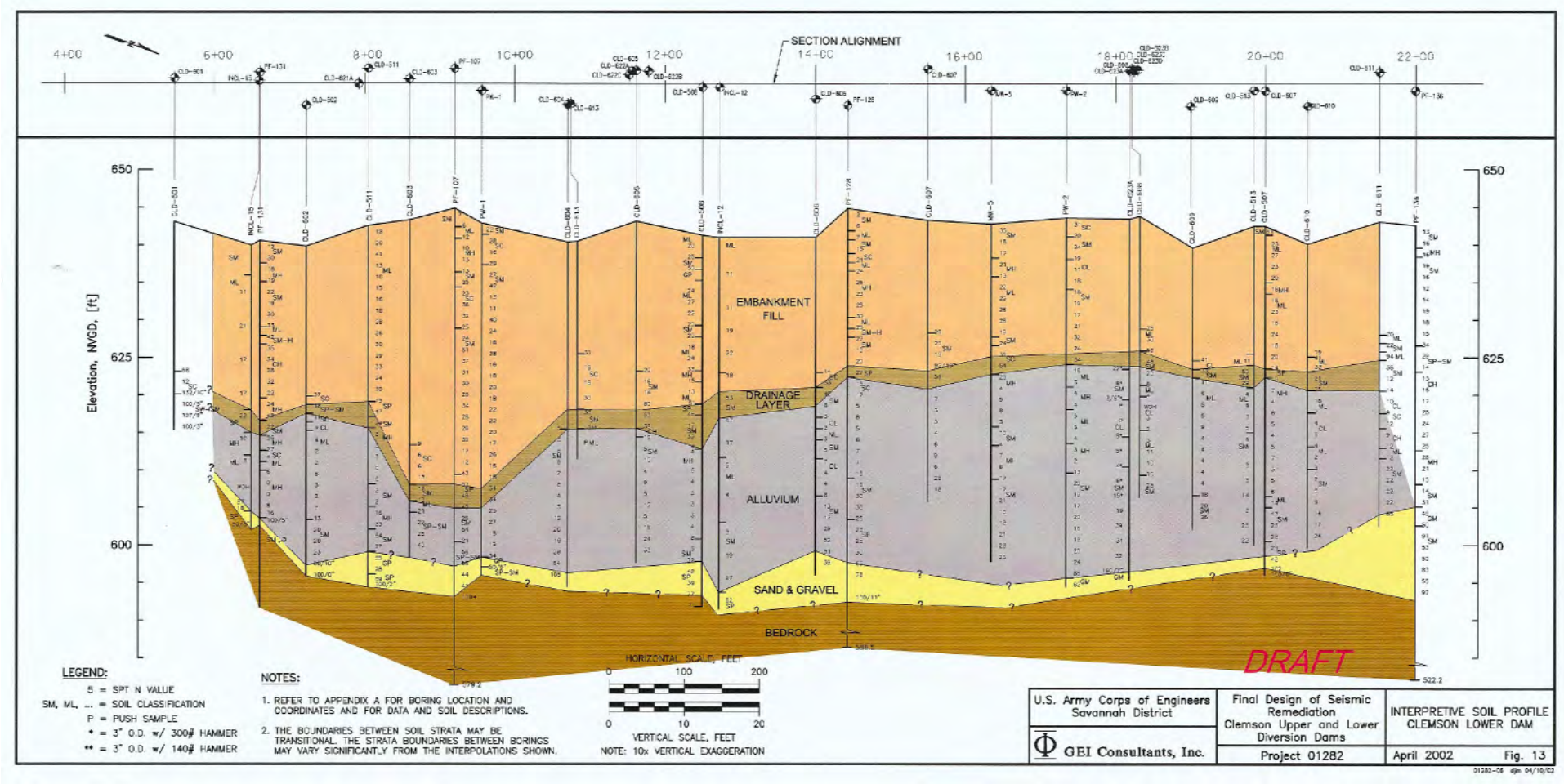


Interpretive Soil Profile – Upper Dam

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Remedial Design



Interpretive Soil Profile – Lower Dam

Remedial Design

U.S. Army Corps of Engineers

GEI Consultants

Design of Soil-Mix Remediation – Design Approach

- Use of **Models**
  - **Steady-State Stability** (post seismic event) – limit equilibrium
    - Assumes liquefaction
  - **Dynamic Stresses & Strains** - Finite Element (TARA, 2D)
    - Evaluates Triggering
    - Provides Peak Stresses and Accumulated Strains during Seismic Event
  - **Peak Strength Stability** (post seismic event) – limit equilibrium
    - Assumes no liquefaction because triggering strains were not reached

Remedial Design

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Design of Soil-Mix – Estimated Shear Stresses

Condition	Soil-Mix Wall Shear Stress
Static - alluvium strength drops to Sus	**82 psi**
Static - alluvium does not lose strength, but soil-mix walls take all stress within remediated zone	**60 psi**
Dynamic - alluvium does not lose strength and load is shared with soil	**55 psi**

Remedial Design

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Factors of Safety

- FS > **1.2** for average alluvial zone remedial strength (2750 psf) and Sus values elsewhere (**liquefaction**)
- FS > **1.65** for average alluvial zone remedial strength (2750 psf) and Sup values elsewhere (**no liquefaction**)
- FS > **~2.5** for **soil-mix** shear wall strengths (≈400 psi)
- FS > **1.1** for **embedment** of shear wall resistance to peak seismic forces

Remedial Design – Construction Requirements

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Soil-Cement in Soil Mix Shear Walls:

f'sc > 77.4 psi x (S / Wa) where:

f'sc = average **compressive strength** of soil-cement

S = soil-cement shear **wall spacing** (center to center), not to exceed 12.5 feet + maximum wall width

Wa = **average wall width**

Remedial Design - Laboratory Investigation

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- Index Testing / Alluvial Soil Characterization
- Soil-Cement Mix Testing
  - Batching
  - Strength Testing
- Undrained Strength Testing of Undisturbed Samples
- Groundwater Testing (for chloride & sulfate levels)

Remedial Design – Lab Testing

U.S. Army Corps of Engineers

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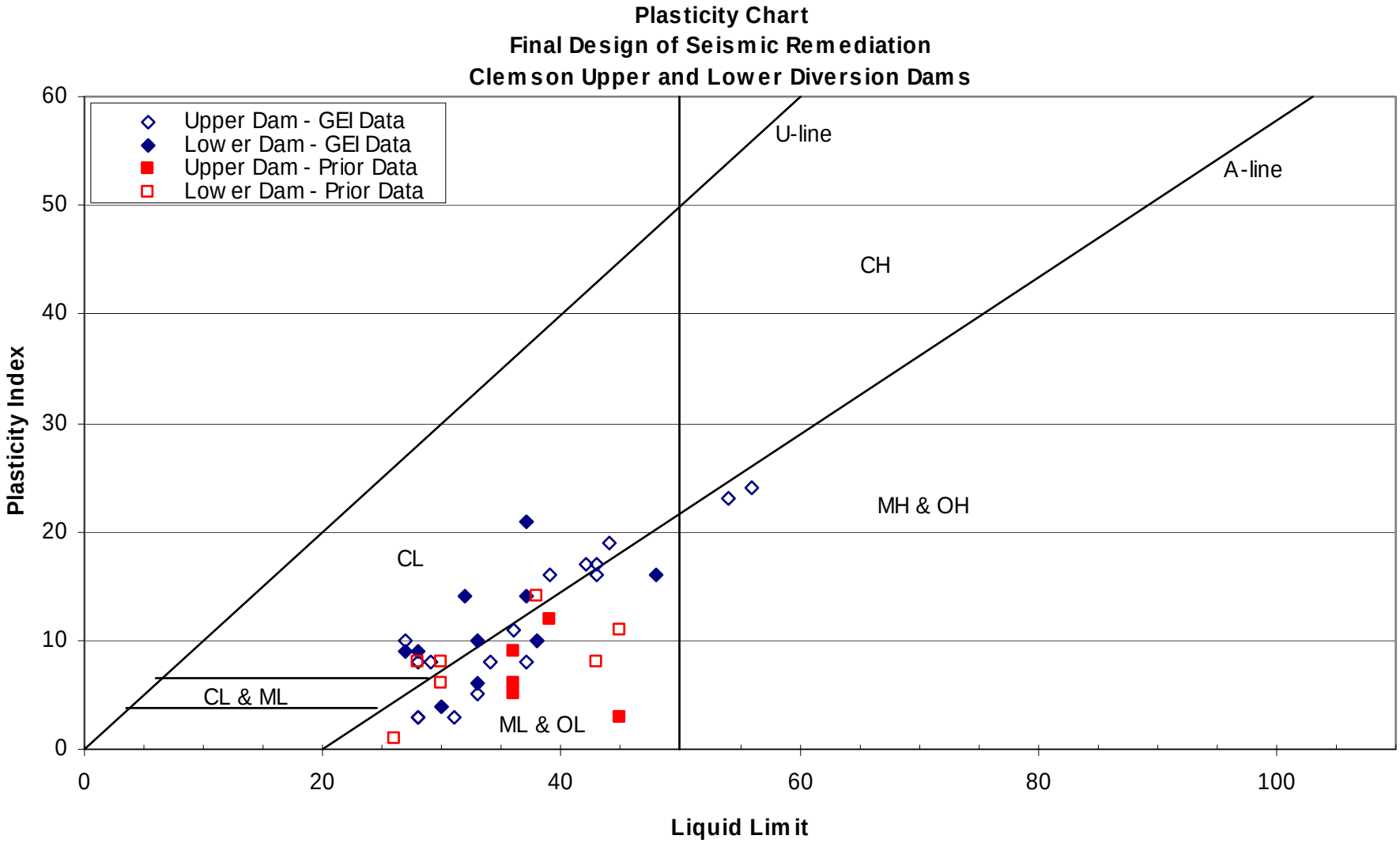
Alluvial Soil Types

- Silty Sand (SM)
- Silty Sand/Sandy Silt (SM/ML)
- Low to Medium Plasticity Silt (ML/MH)
- Clay (CL)
- Silty Sand/Sandy Silt with Organics (SM/ML-O)

Remedial Design – Plasticity Tests Summary Plot

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Remedial Design – Lab Testing

Mixing soil and grout



Remedial Design – Lab Testing

Silty sand specimen at failure



Remedial Design – Lab Testing

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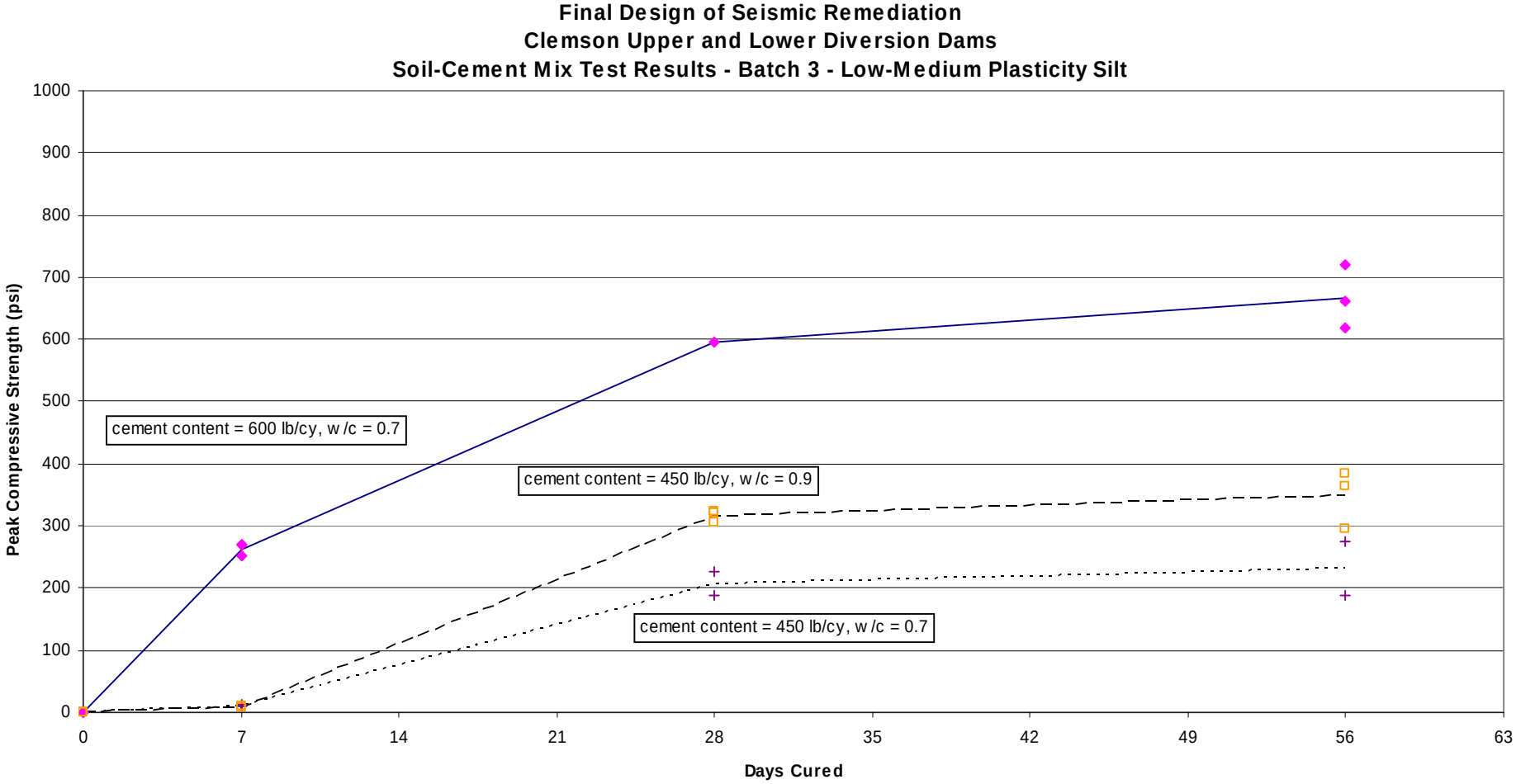
Batch #	Description	Cement Content for w/c = 0.7		
		300 lbs/cy	450 lbs/cy	600 lbs/cy
1	Silty Sand	X	X	
2	Silty Sand/Sandy Silt		X	X
3	Low to Medium Plasticity Silt		X(1)	X
4	Clay		X	X
5	Silty Sand/Sandy Silt with Organics			X

Soil-Cement Test Program

Remedial Design – Lab Testing

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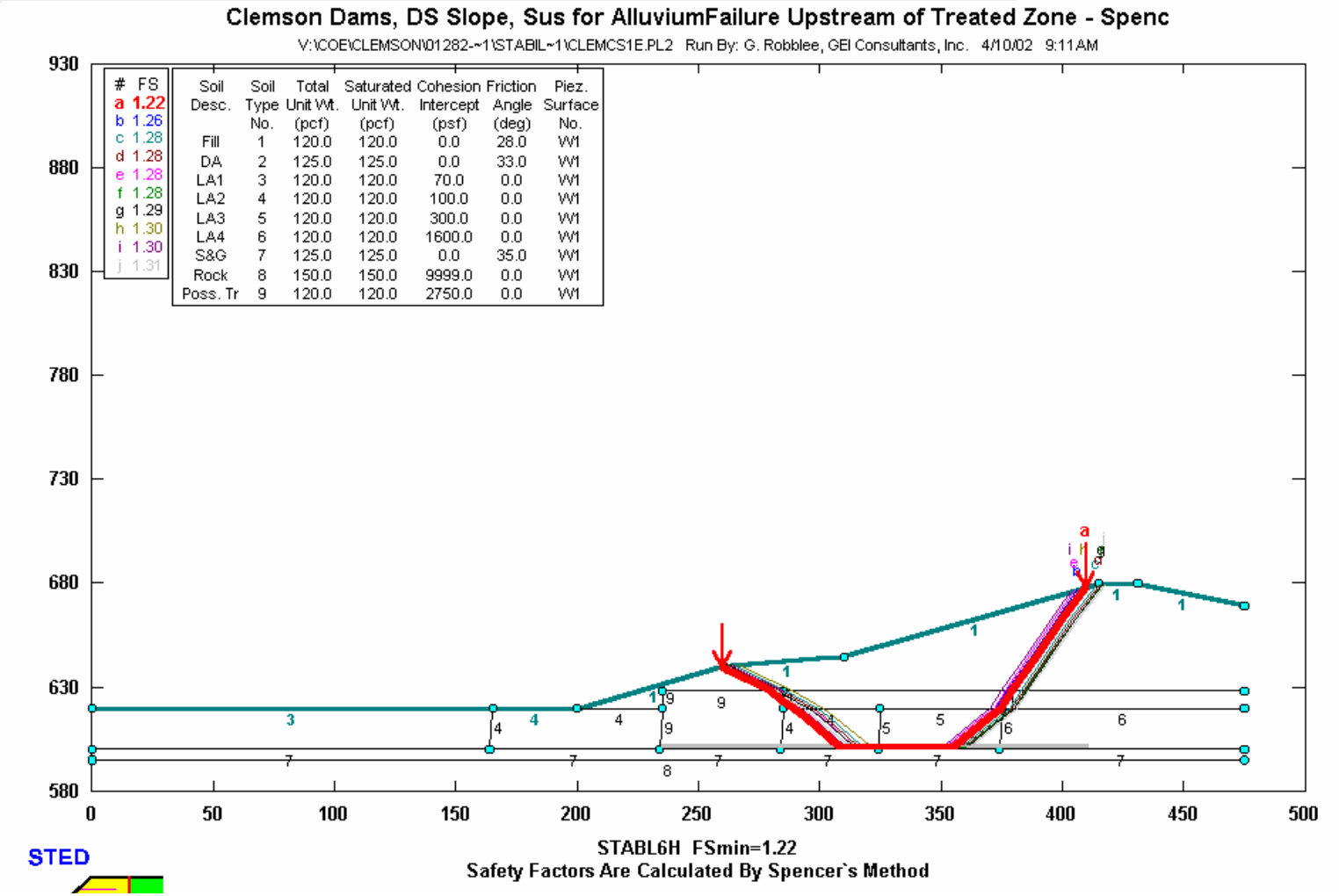


Strength Test Summary
Low-Medium Plasticity Silt

Remedial Design – Position of Soil Mix Shear Walls

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Sus FS = 1.2, Failure Upstream of Shear Walls

Remedial Design – Shear Wall Embedment

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- **Purposes:**
  - Prevent potential interface failures
  - Transmit seismic stresses between these strata and the walls without excessive movement
- **FS > 1.1** for resistance to **peak seismic forces**
- **Design embedment** of the soil-cement walls into
  - Overlying berm is **8 feet**
  - Underlying sand and gravel is **4 feet**

Remedial Design – Longitudinal Wall

U.S. Army Corps of Engineers

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- **Purpose:** Reduce movement potential of soil between transverse walls
- **Notes:**
  - Shear strength (Sup) of soil between shear walls sufficient to prevent relative slippage between soil and walls
  - Longitudinal walls decrease soil strains, and thus make it even less likely that the soil strength would decrease to Sus
  - Design does not include longitudinal walls in dense alluvium areas of former river channel

Remedial Design – Drainage System

U.S. Army Corps of Engineers

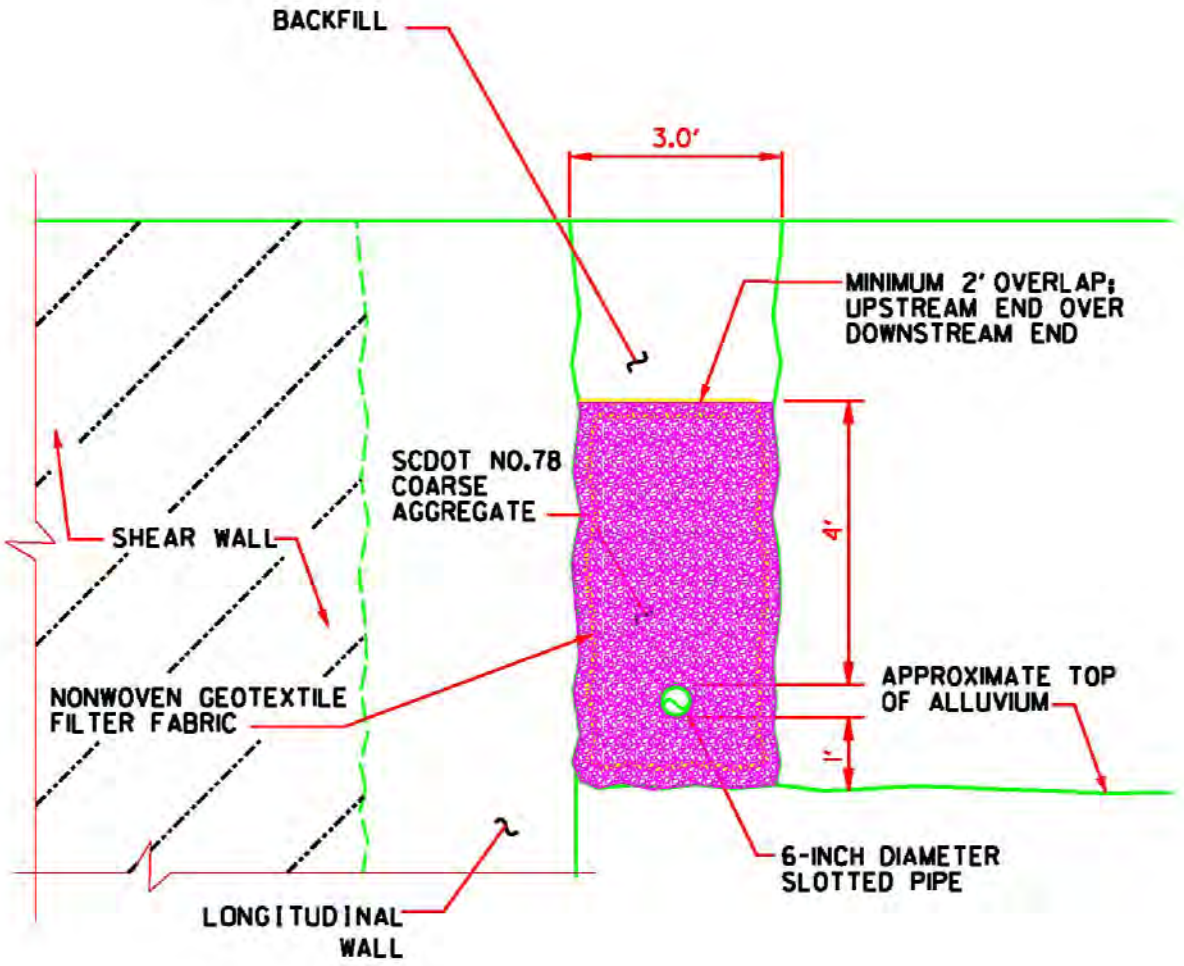
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- **Purpose:** Prevent buildup of pore pressures upstream of longitudinal wall
- **Filtered seepage collection system** upstream of the longitudinal wall:
  - **Slotted pipes surrounded by gravel and geotextile**
  - **Elevations of system selected to intercept blanket drain**
  - **Discharge piping to ditches and ponds beyond toes of dams**

Remedial Design-
Drain Details

U.S. Army Corps of Engineers

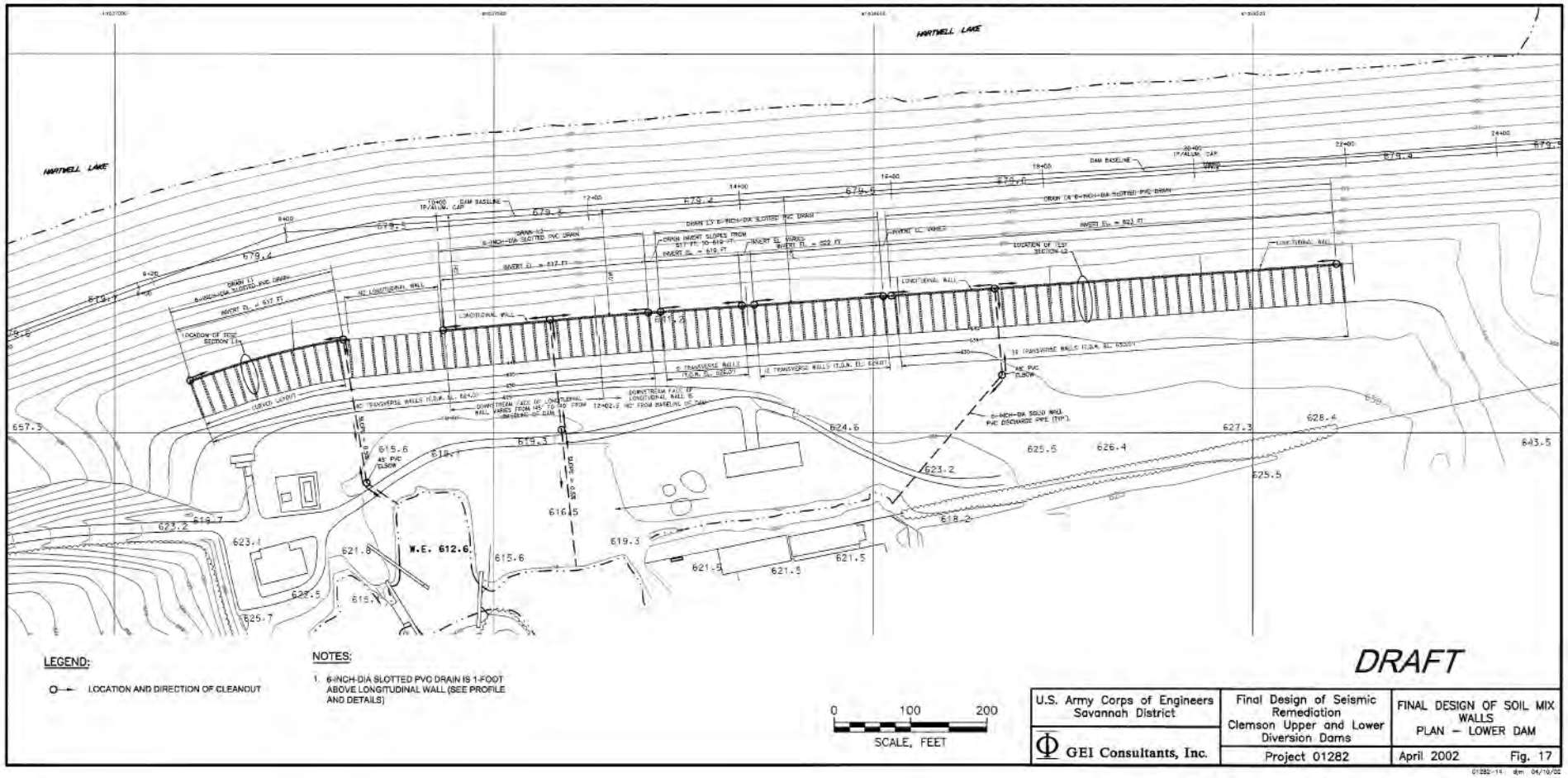
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Remedial Design – Lower Dam Plan

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GEI Consultants

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SEISMIC REMEDIATION OF THE CLEMSON UPPER AND LOWER DIVERSION DAMS; DEEP SOIL MIX CONSTRUCTION

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GEI Consultants, Inc.
Winchester, MA

Ben Foreman
U.S. Army Corps of Engineers
Savannah District

Bids

Clemson Total Bid Summary			Production Soil Cement Bid Summary	
Government Estimate	$7,768,587		Winning Bid	$107/yard^3
Winning & Low Bid	$7,744,657		Low Bid	$70/yard^3
High Bid	$12,592,400		High Bid	$199/yard^3
Average	$9,248,526		Average	$126/yard^3

Winning Bid: **RAITO Inc.** of Crofton, Maryland

Bids

Additional Soil Cement Bid Summary	
Winning & Low Bid	$220/yard^3
High Bid	$819/yard^3
Average	$556/yard^3

Construction – Soil Mix Equipment

- Large track mounted rig
- Six in-line, 3-foot-diameter, ~50-foot-long soil mix augers
- Four electrical motors drive the augers at either 20 or 40 rpms



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

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- Auger mixing blades over the bottom 10 ft of the shafts
- Overlap adjacent mixing columns by 1 ft
- Average wall width of 2.76 feet
- Adjacent augers vertically offset by 1 ft



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

GEI Consultants



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

GEI Consultants

Batch and Pumping Plant



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

GEI Consultants



Tanker truck off-loading cement

Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

GEI Consultants



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

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Pump

Flow Meters



Construction – Soil Mix Equipment

U.S. Army Corps of Engineers

GEI Consultants



Construction – QA/QC

U.S. Army Corps of Engineers

GEI Consultants

Monitored Parameters:

- Depth
- Time
- Flow Rate

→ Injected Cement / Foot

- Cable Load
- Electrical Motor Load

→ Resistance

- Verticality

U.S. Army Corps of Engineers

GEI Consultants

Typical Installation Record

Installation Records

Project Name: Clemson

Element # : UDSW40196 Rig # : 1 7 / 28 / 2004

Mixing System Design Data	Depth (ft)	Slurry Injection Volume (gal/ft)		Speed (ft/min)	
		Down	Up	Down	Up
1st Layer	8.5	1.0	0.0	40.0	40.0
2nd Layer	50.0	17.6	0.0	3.5	5.5
3rd Layer	-----	-----	-----	-----	-----
4th Layer	-----	-----	-----	-----	-----

Depth (ft)	Time (mm:ss)	Speed (ft/min)	Rotation (rpm)	Slurry Injection Volume (gal)					Energy Index	
				Column2	Column3	Column4	Column5	Column6		
0.0	0:00									
3.0	0:25	7.2	19	7.1	7.2	8.4	7.4	7.5	39	
6.0	1:58	1.5	19	22.7	20.7	21.8	22.3	22.6	222	
8.5	3:50	0.6	17	73.1	73.5	74.3	71.1	74.3	805	
9.0	0:24	1.2	19	18.3	18.3	18.1	18.5	18.3	377	
12.0	1:27	2.0	19	54.4	54.3	54.4	54.5	54.3	198	
15.0	1:27	2.0	19	52.3	52.2	52.1	52.2	52.3	194	
18.0	1:13	2.4	19	58.3	57.3	58.4	58.0	58.1	144	
21.0	1:08	2.6	19	64.4	63.2	64.5	64.5	64.4	76	
24.0	0:56	3.2	38	53.4	55.2	53.3	53.4	53.4	40	
27.0	1:37	1.8	40	58.6	58.7	58.6	58.1	57.3	110	
30.0	1:04	2.8	40	54.3	56.0	53.7	56.6	57.4	35	
33.0	1:05	2.7	40	56.6	57.3	54.9	57.1	56.9	36	
36.0	3:00	1.0	39	59.8	61.0	60.6	60.6	62.3	275	
39.0	1:30	2.0	21	75.5	81.2	79.5	81.2	82.0	84	
42.0	0:57	3.1	19	53.8	53.9	53.8	53.9	53.8	96	
45.0	2:14	1.3	19	63.5	63.6	63.1	64.1	63.8	348	
47.0	3:58	0.5	19	110.4	112.3	40.6	39.6	40.2	1069	***
47.5	1:31	0.0	19	34.2	34.2	32.4	32.8	30.9	1337	
48.0	0:31	4.0	19	0.5	0.5	0.5	0.5	0.5		**

Construction-QA/QC

U.S. Army Corps of Engineers

GEI Consultants



Construction – Planned QA/QC

U.S. Army Corps of Engineers

GEI Consultants

QA/QC – Wet Grab Soil-Cement Samples

Frequency:

- Two sets of samples per wall
- Not less than one set per work shift per rig

Set: Consists of 4 samples each at top, middle, bottom depths

Procedure:

- Screen samples on 1-inch sieve
- Cut particles retained to just pass the 1-inch sieve and then to be remixed with sample
- Collect enough soil-cement per sample to make four full cylinders (6-inch diameter by 12-inch height)

Unconfined tests: @ 7 days, 28 days(2), and 56 days; (12 @ 28)

Construction – Planned QA/QC

U.S. Army Corps of Engineers

GEI Consultants

QA/QC - Core Samples

Where:

- Two locations per test section (Test section was a single wall)
- Two locations within any production wall where wet grab samples do not meet strength criteria

When: Only after strength from unconfined tests on wet grab cylinders indicate that soil-cement strength is unsuitable

Type of core: Continuous, double tube or triple tube, minimum 3-inch diameter

Supplemental coring: If recovery less than 85 % in any run

Testing: Unconfined compression on six samples per boring

Construction – QA/QC

U.S. Army Corps of Engineers

GEI Consultants

Test Sections

Two test sections per dam.

Establish **base procedures** for installation of production walls.

If **f'sc < criteria**, then:

- use **smaller S**, wall spacing, that will meet criterion or
- Contractor may **modify procedures** (e.g. higher cement ratio) during production to increase f'sc.

Construction – Planned QA/QC

U.S. Army Corps of Engineers

GEI Consultants

QA/QC – Soil-Cement Strength Criteria

Average 28-day compressive strength for each wall:

- **Average f'sc** (28 day) =/> 77.4 psi x (S / Wa)

  Average of all samples (12) from six wet grab locations or all samples (12) from two core borings (when wet grab samples fail)

- **One sample** per wall may have **f'sc < 2/3 criterion**

Construction – QA/QC

U.S. Army Corps of Engineers

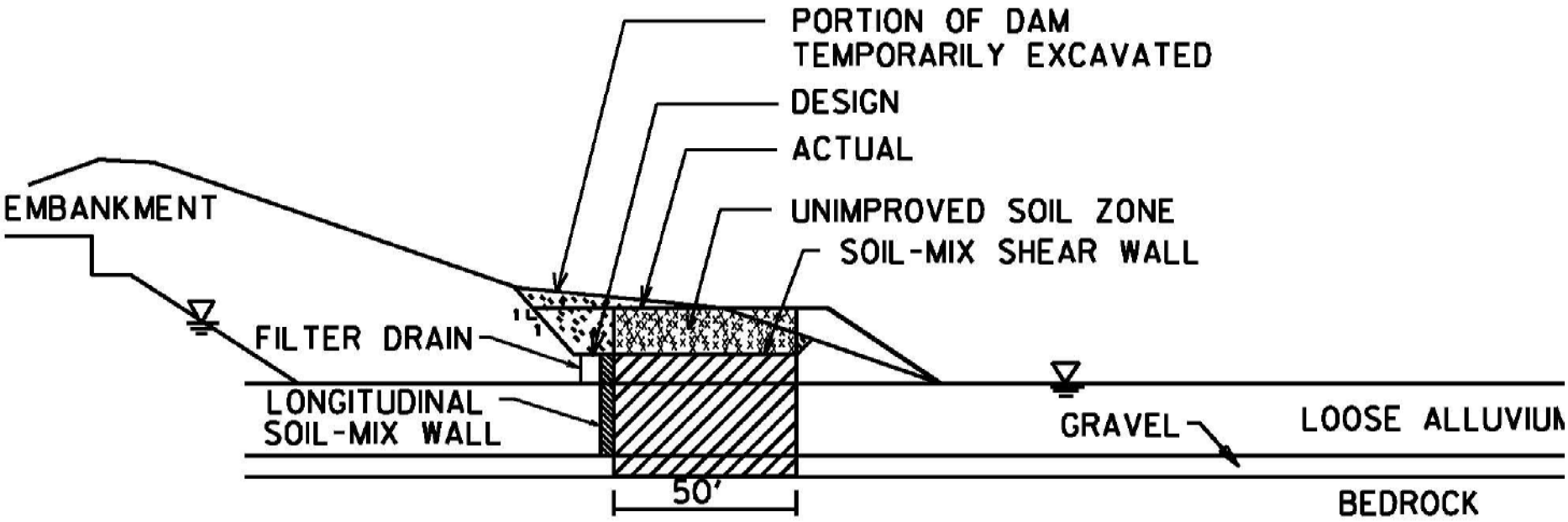
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Construction-
Excavation of Berm

U.S. Army Corps of Engineers

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Design vs Actual – Schematic Section

Construction- Excavation of Berm

U.S. Army Corps of Engineers

GEI Consultants



Construction-QA/QC

U.S. Army Corps of Engineers

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Sampler plugged with soil from unimproved zone

Construction-QA/QC

U.S. Army Corps of Engineers

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Construction – QA/QC

Attempts at Wet-Grab Sampling (Unsuccessful)



Construction – QA/QC

Coring Rig for Soil-Cement Sampling



Construction-QA/QC

U.S. Army Corps of Engineers

GEI Consultants



Construction-QA/QC

U.S. Army Corps of Engineers

GEI Consultants



Core in core box; note plastic sheath and burlap

Construction-QA/QC

U.S. Army Corps of Engineers

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Logging of core and selecting test specimens

Construction – Actual QA/QC

U.S. Army Corps of Engineers

GEI Consultants

QA/QC – Soil-Cement Strength Criteria

Average 28-day compressive strength for each wall:

- **Average f'sc** (28 day) =/> 77.4 psi x (S / Wa)

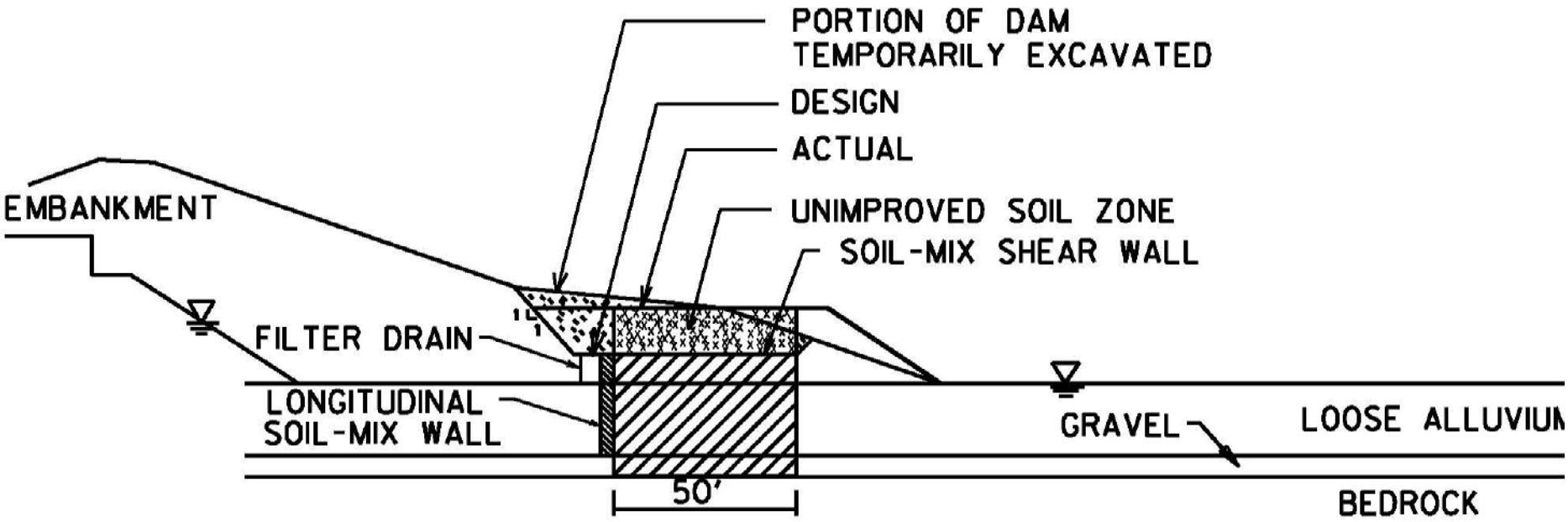
Average of all samples (12) from six wet grab locations or all samples (12) from two core borings (when wet grab samples fail)

- **One sample** per wall may have **f'sc < 2/3 criterion**
- ***Criteria evolved to single core boring for a day's production; minimum six samples per core; one sample may have f'sc < 2/3 average; additional core borings as required***

Construction-
Excavation of Berm

U.S. Army Corps of Engineers

GEI Consultants



Design vs Actual – Schematic Section

Construction-
Drain Construction

U.S. Army Corps of Engineers

GEI Consultants



Trench box and dewatering pump station

Construction-
Drain Construction

U.S. Army Corps of Engineers

GEI Consultants



Installation of discharge line; note slot in longitudinal wall

Construction-
Drain Construction

U.S. Army Corps of Engineers

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Cleanouts on drain line



Construction – Soil-Cement Production Mixes

U.S. Army Corps of Engineers

GEI Consultants

Cement Injection Rates:

- **840 lb/yd^3** (500 kg/m^3) at start
- **670 lb/yd^3** (400 kg/m^3) at end

Water-Cement Ratio: **0.6 to 0.7**

Construction – Penetration “Refusal” Criteria

U.S. Army Corps of Engineers

GEI Consultants

- Advancement Rate < 0.2 foot/minute
- Cable load < one ton
- Duration > one minute

Construction- Problems and Remedies

U.S. Army Corps of Engineers

GEI Consultants

Problems:

- Zones where f'sc of soil cement did not meet criteria, probably due to organic content and/or low pH, in ~13% of walls
- Difficult to judge and achieve **penetration** into dense strata, in ~20% of walls

Remedy:

- **Additional elements** or walls

Construction – Lessons

U.S. Army Corps of Engineers

GEI Consultants

- **Expect zones of significant deviation** of f'sc (allow some random deviations, correct deviation trends or patterns)
- **Cover as large a range of soils** as possible in design mix testing
- Test soil samples for **pH** and **organic content**
- Use **coring** and not wet grab sampling for QA
- Use **recovery** and core **RQD** or continuity as part of the QA criteria

Construction – Lessons

U.S. Army Corps of Engineers

GEI Consultants

- Include a defined number of **additional soil borings** and **core borings** as part of the construction program
- Define **required remedial actions** if f'sc is low or if penetration is not achieved
- Require use of **computerized data collection and injection control** for QC

Summary – Design & Construction

U.S. Army Corps of Engineers

GEI Consultants

The use of soil mix shear walls to provide reinforcing of the loose soil against seismic deformations and liquefaction shear slides at the Clemson Dams was feasible and cost effective

U.S. Army Corps of Engineers

GEI Consultants

Clemson Diversion Dams









Clemson University can continue to safely perform Football Rituals in Death Valley.



SEEPAGE COLLECTION & CONTROL SYSTEMS: THE DEVIL IS IN THE DETAILS

Presented by

John W. France, PE

URS Corporation

Denver, Colorado

2005 Tri-Service Infrastructure Conference & Exhibition

"Re-Energizing Engineering Excellence"

August 2 through 4, 2005

St. Louis, Missouri

WHY IS THIS IMPORTANT?

- Seepage is the second leading cause of dam failures
- Seepage collection and control systems are a common rehabilitation solution
- Seepage collection and control systems are typically included in dam enlargements and new dams
- These systems are key elements in safety of a dam
- Success of systems depends on the details

SPECIFIC DETAILS TO BE DISCUSSED

- Drain pipes embedded in sand
- Verification of pipe installation
- Access to pipes for inspection and maintenance
- Sand filter gradations
- Use of standard gradations
- Chimney drain width
- One-stage versus two-stage filters

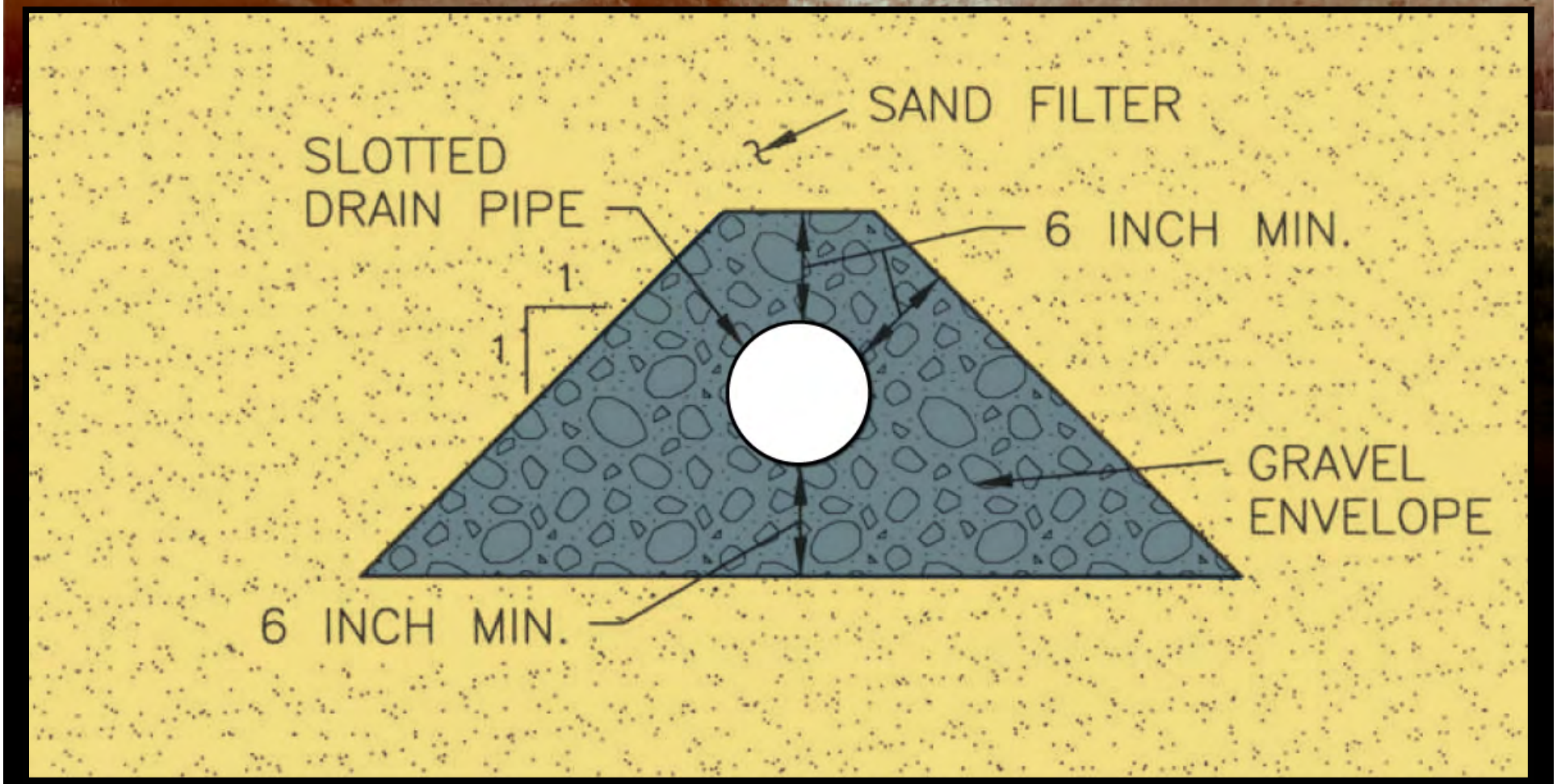
DRAIN PIPES EMBEDDED IN SAND

- Have been used on many dams
- Author has used them
- Recent experience has indicated potential problems

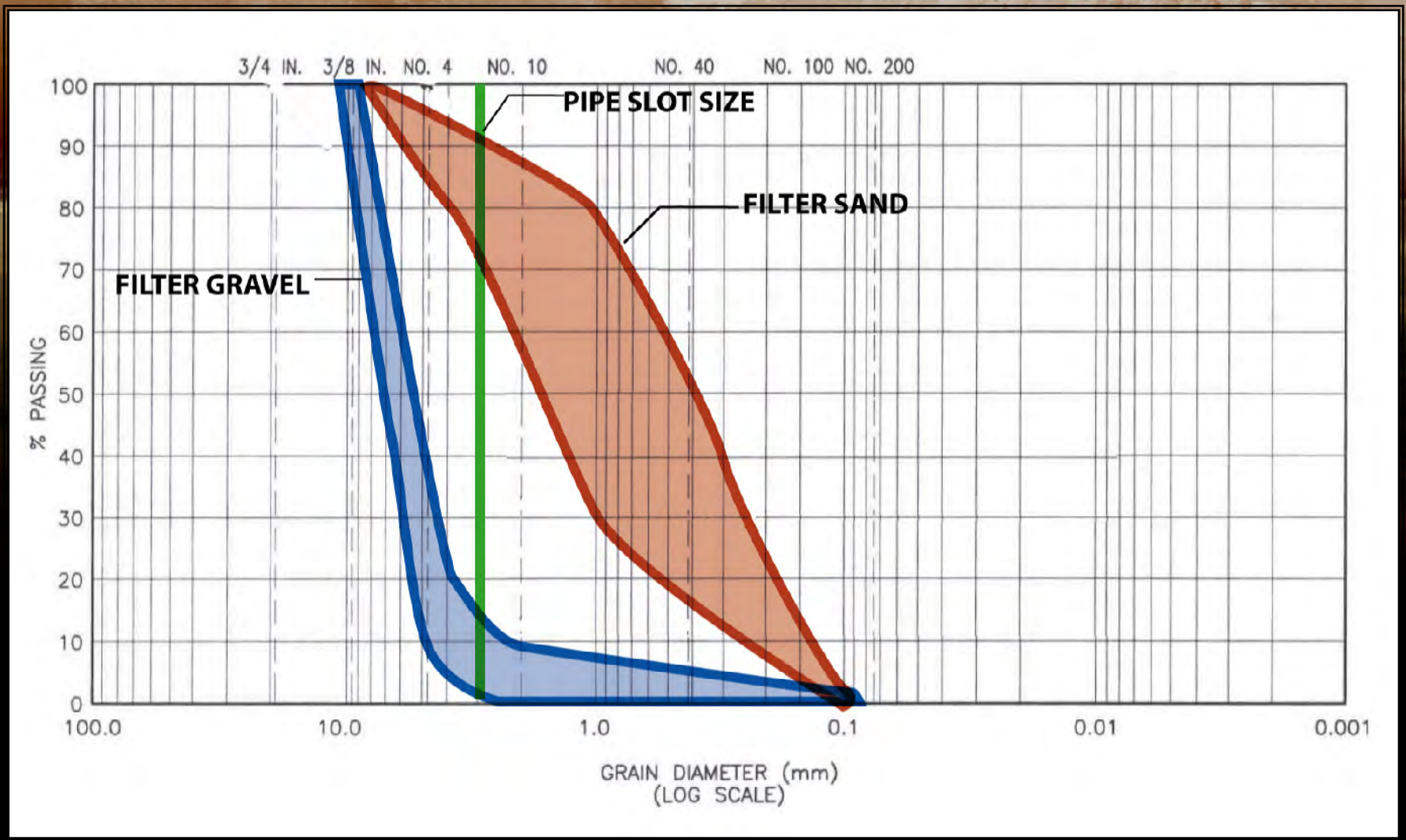
EXAMPLE

- 6-inch diameter pipes with 0.02 inch slots, embedded directly in sand chimney
- ASTM C33 fine aggregate sand
- Sand and pipe slots designed according to current filter criteria
- With 10 feet of head in the chimney, flow through the slots was limited (less than 30 gpm)
- Limited flow confirmed with camera survey
- Replaced with pipes in gravel – produced > 500 gpm
- Similar experience reported by others

RECOMMENDED DESIGN – PIPE IN GRAVEL ENVELOPE



EXAMPLE – PIPE IN GRAVEL ENVELOPE



ADVANTAGES OF RECOMMENDED DESIGN

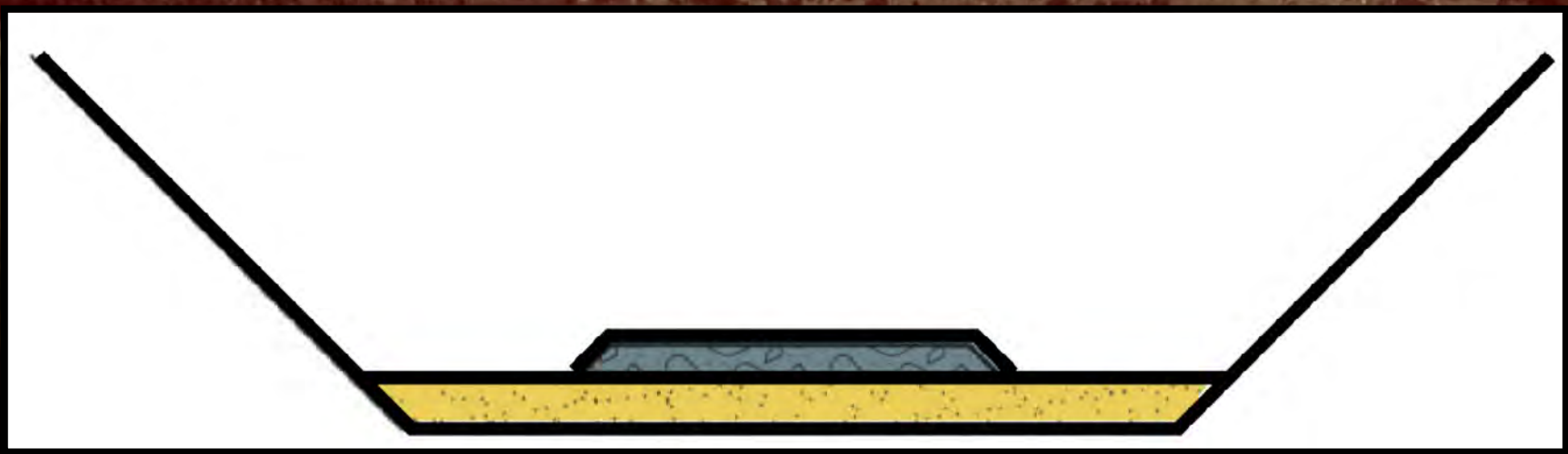
- Water flows freely
  - Sand to gravel
  - Gravel to pipe
- Pipe capacity is fully realized
- Gravel allows for larger pipe slots – less prone to clogging

Design is more expensive, but much more robust!

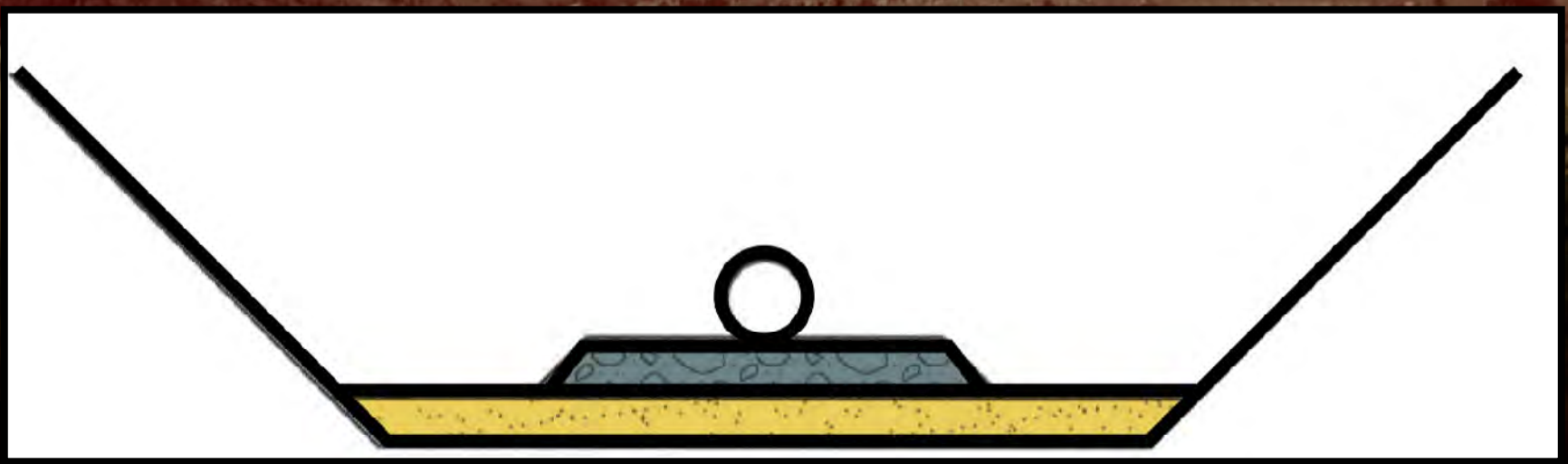
PRACTICAL CONSTRUCTION SEQUENCE



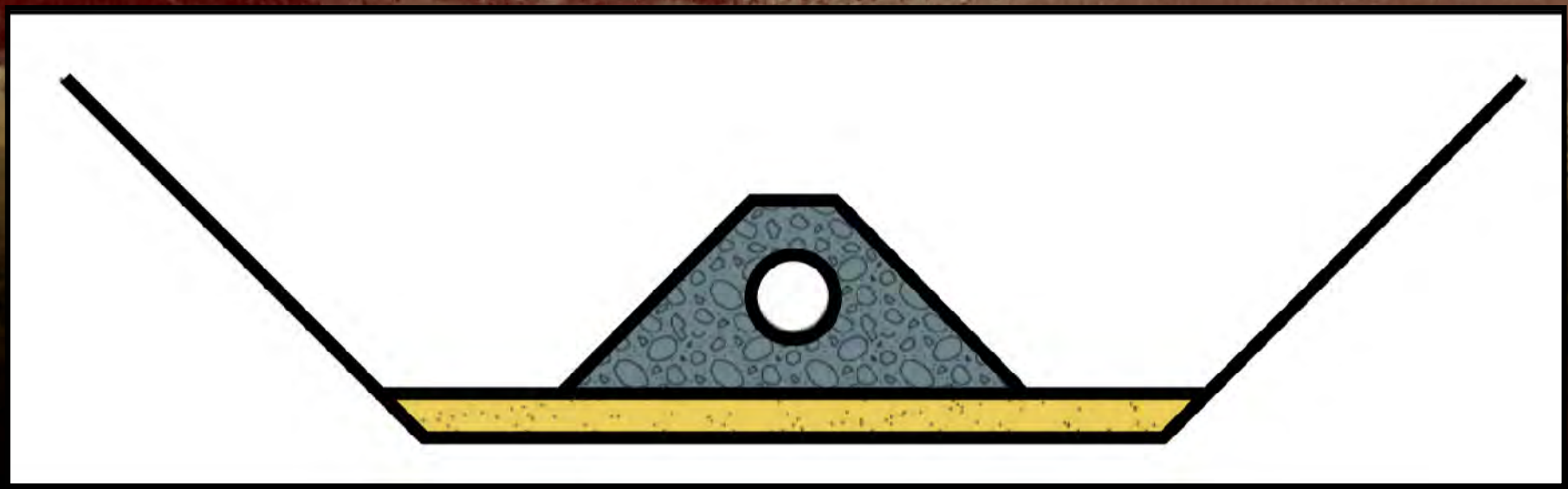
PRACTICAL CONSTRUCTION SEQUENCE



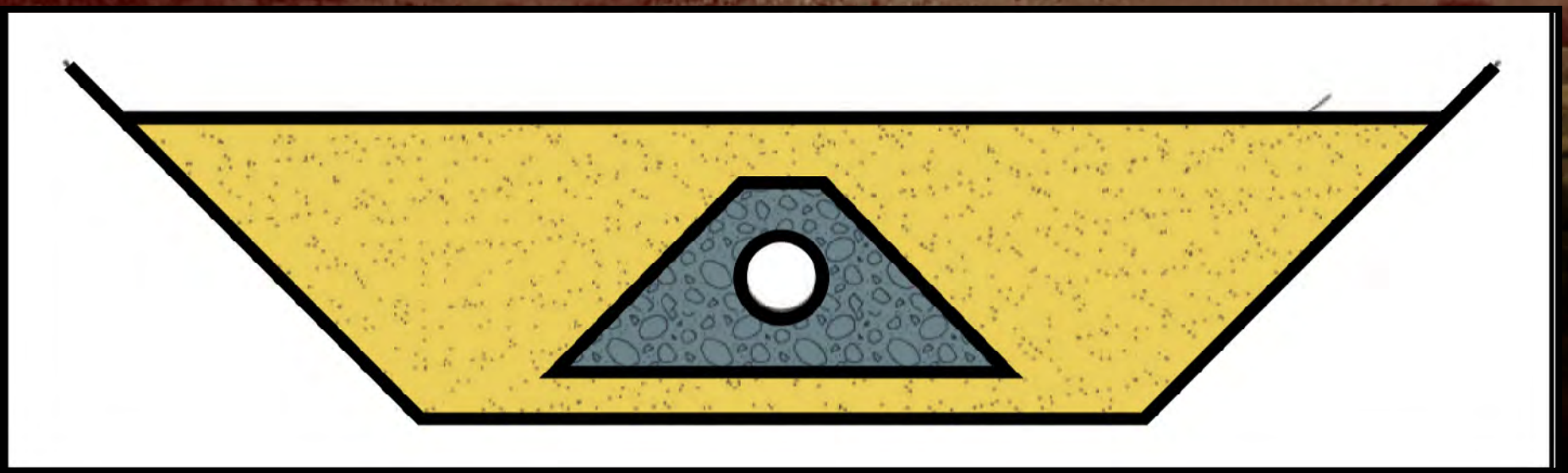
PRACTICAL CONSTRUCTION SEQUENCE



PRACTICAL CONSTRUCTION SEQUENCE



PRACTICAL CONSTRUCTION SEQUENCE



UNCERTAINTIES WITH GEOTEXTILE SLEEVES

- May improve flow into slotted pipes
- Susceptible to installation damage
- May clog or deteriorate
- Not accepted by all regulators
- Not as robust as gravel envelope

VERIFICATION OF DRAIN PIPE INSTALLATION

- Important to verify undamaged installation
- Important to verify at a time when corrective actions are practical
- Damage could include:
  - Open joints
  - Cracked or punctured walls
  - Crushed or distorted pipes

SPECIFICATIONS AND OBSERVATION

- Compaction limitations in the vicinity of the pipe
- Observation of installation
- With limitations and full-time observation, damage is still possible

EXAMPLE

- 12-inch diameter pipe in gravel envelope
- Installed with qualified, full-time observation
- Puncture in the pipe wall occurred
- Likely due to construction equipment impact

RECOMMENDED VERIFICATION

- Camera survey
  - With no more than 3 to 5 feet of fill
  - After completion of construction
- Cameras preferred over torpedoes or balloons
  - Need to verify condition as well as continuity
  - Camera costs are reasonable

ACCESS TO DRAIN PIPE

- Access for future inspection and maintenance is highly desirable
- Need to avoid long sections and inaccessible ends
- Design to accommodate internal camera surveys will provide adequate access
  - Minimum 6-inch diameter
  - Manholes or cleanouts at 500- to 1,000-foot intervals
  - Bends no sharper than 22.5 degrees
  - Sufficient straight sections between bends

SAND FILTER GRADATION

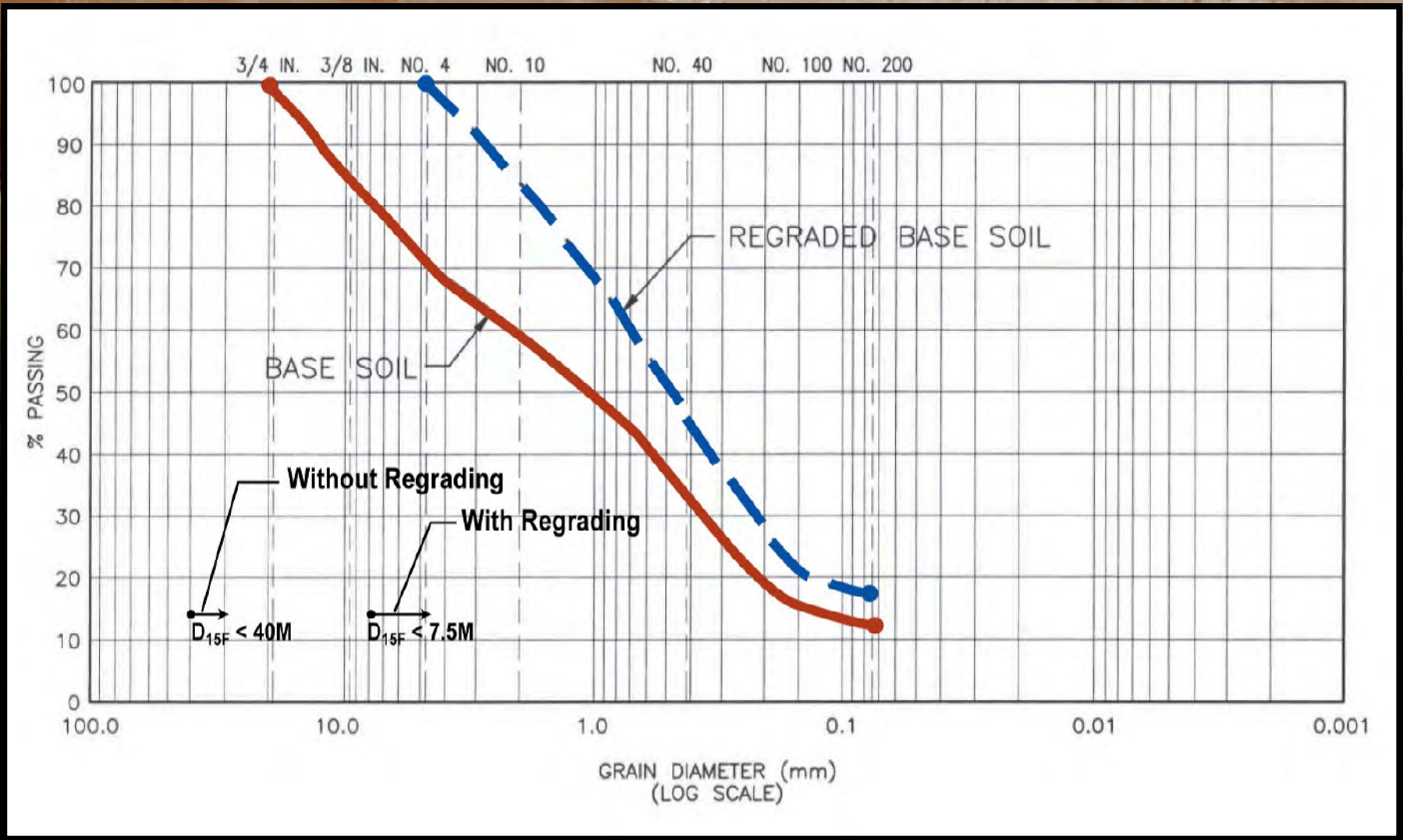
- Key factor in a successful seepage collection and control system
- Must prevent piping of all embankment and foundation soils
- Based on most recent design guidelines: NRCS (1994), USBR (1999), USACE (1993)
  - Base soils divided into four categories
  - Regrading of base soil

BASE SOIL CATEGORIES

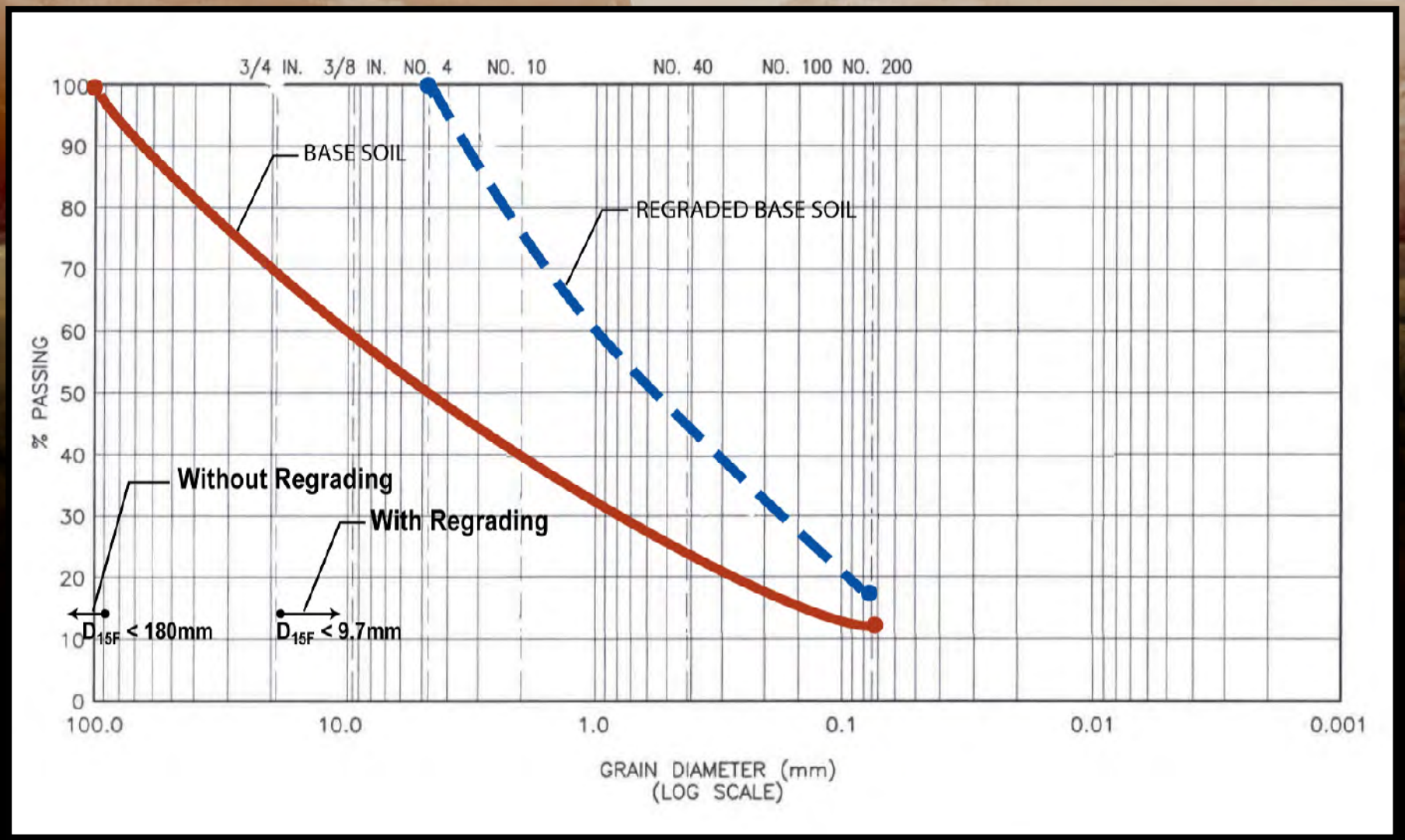
Criteria for Filters and Base Soil Categories, from USBR (1999)

Base Soil Category	Percent Finer than No. 200 sieve	Base Soil Description	Filtered Criteria
1	>85	Fine silts and clays	$D_{15}F \leq 9 \times D_{85}$, but not , 0.2mm B
2	40 – 85	Sands, silts, clays, and silty and clayey sands	$D_{15}F \leq 0.7$ mm
3	15 – 39	Silty and Clayey sands and gravels	$D_{15}F \leq 0.7 \text{ mm} + \frac{(40-A)(4 \times D_{85}B - 0.7m)}{25}$
4	<15	Sands and gravels	$D15F \leq 4 \times D_{85}B$

BASE SOIL REGRADING No. 1



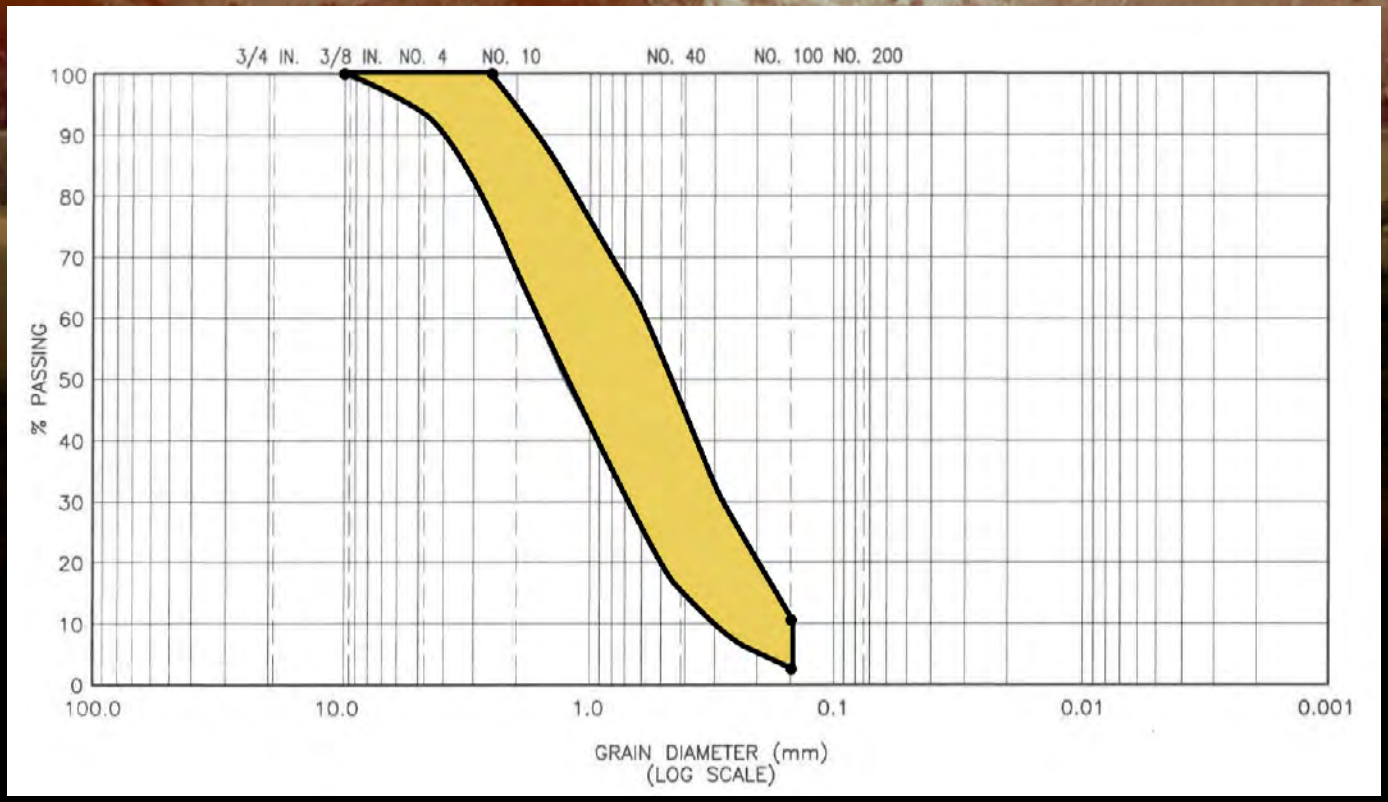
BASE SOIL REGRADING No. 2



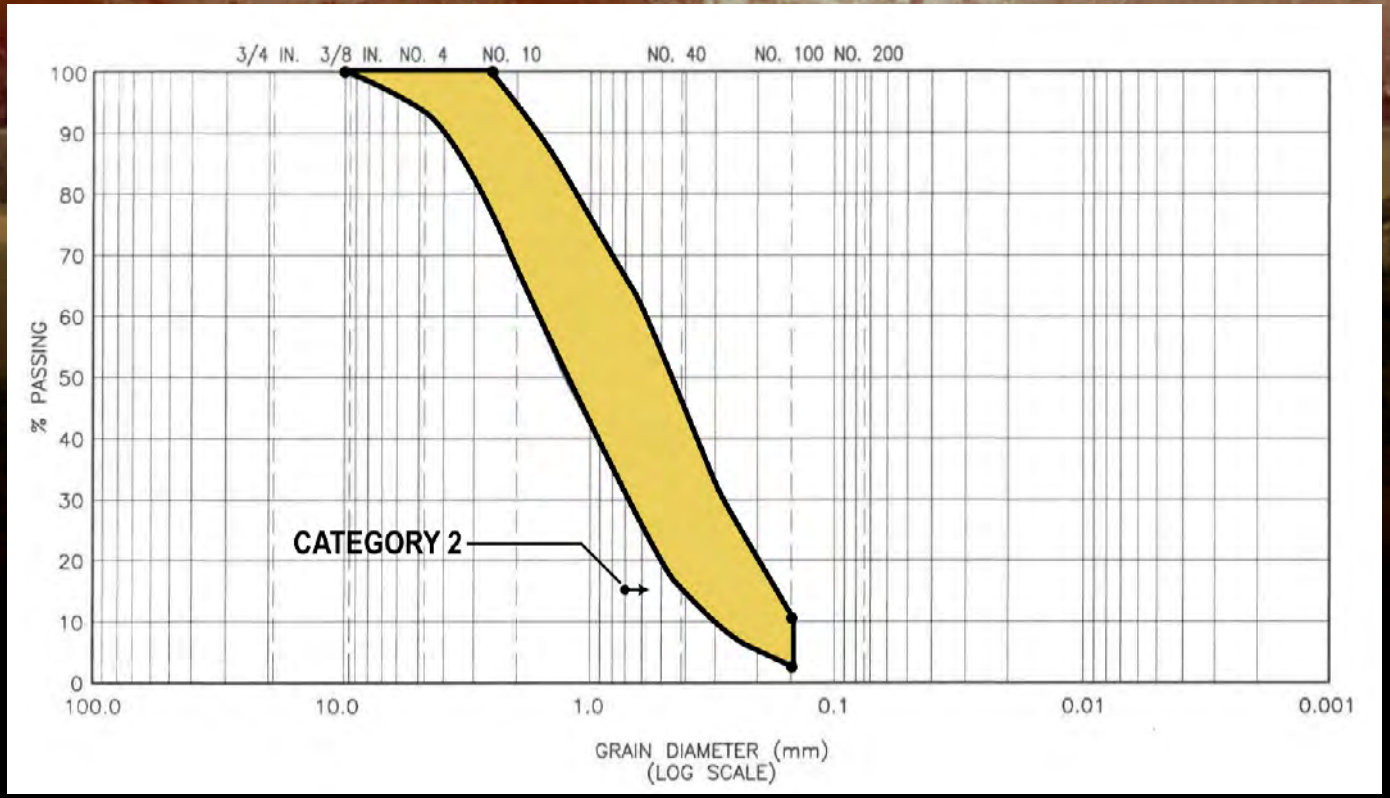
USE OF ASTM C33 FINE AGGREGATE

- Suitable for almost all base soils
- Readily available from commercial sources in most locations
- Must add a 200 sieve size requirement to specifications
- Similar gradations can be used, if available at less cost
- May not be suitable for some clays and silts (Category 1 base soils)

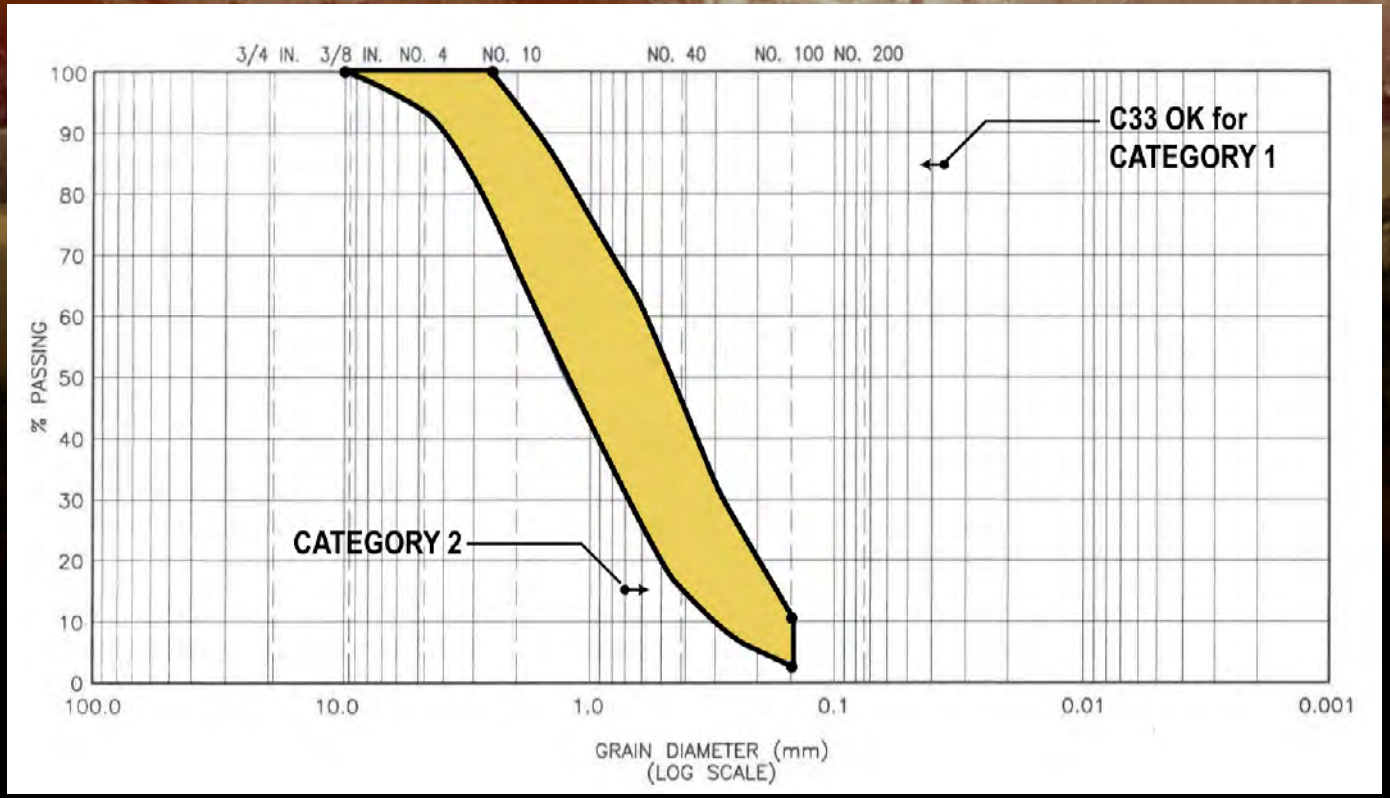
ASTM C33 FINE AGGREGATE SAND



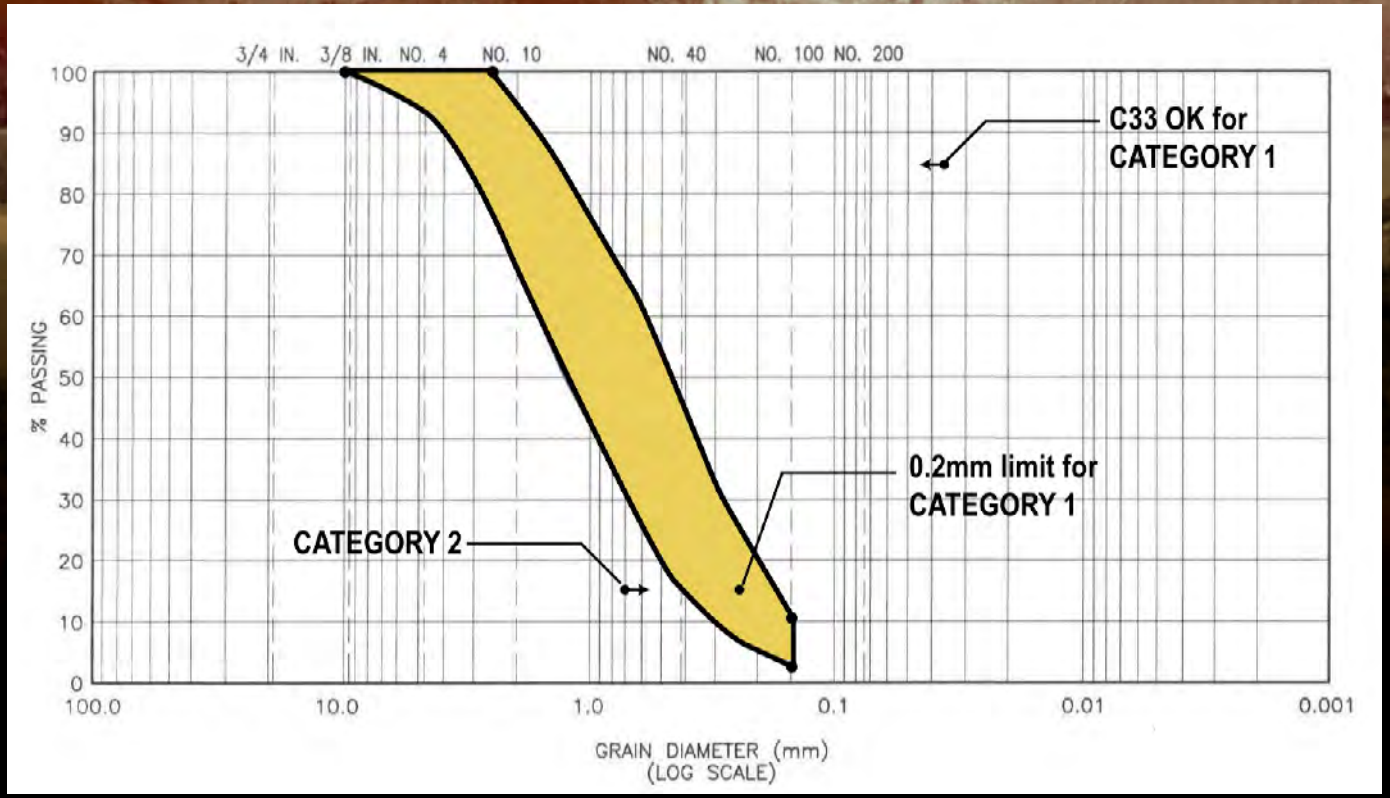
ASTM C33 FINE AGGREGATE SAND



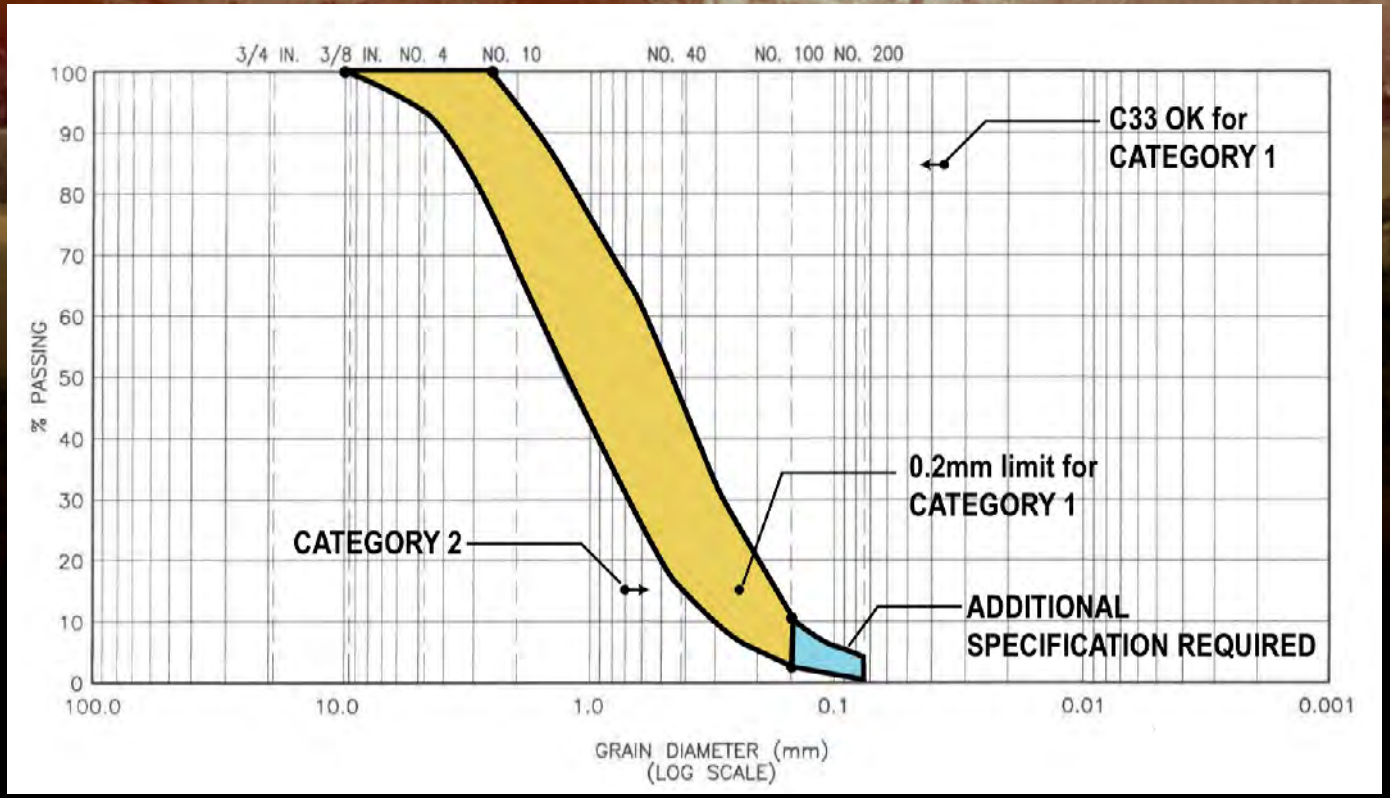
ASTM C33 FINE AGGREGATE SAND



ASTM C33 FINE AGGREGATE SAND



ASTM C33 FINE AGGREGATE SAND



USE OF STANDARD GRADATIONS

- Advantageous if off-site sources are anticipated
- Specify locally available sand and gravel materials that fall within the latitude in the filter requirements
- Sources for standard gradations include:
  - State DOT specifications
  - AASHTO gradations
  - ASTM gradations
  - Products of local aggregate producers
- Verify local availability

CHIMNEY DRAIN WIDTH

- Recent trend toward smaller widths – inclined filters 2- to 3-feet wide
- False economy, if effectiveness of filter is compromised
- Constructability and construction QC must be considered in design
- Misalignment of layers can cause lack of continuity


AS CONSTRUCTED
DESIGN LIMITS

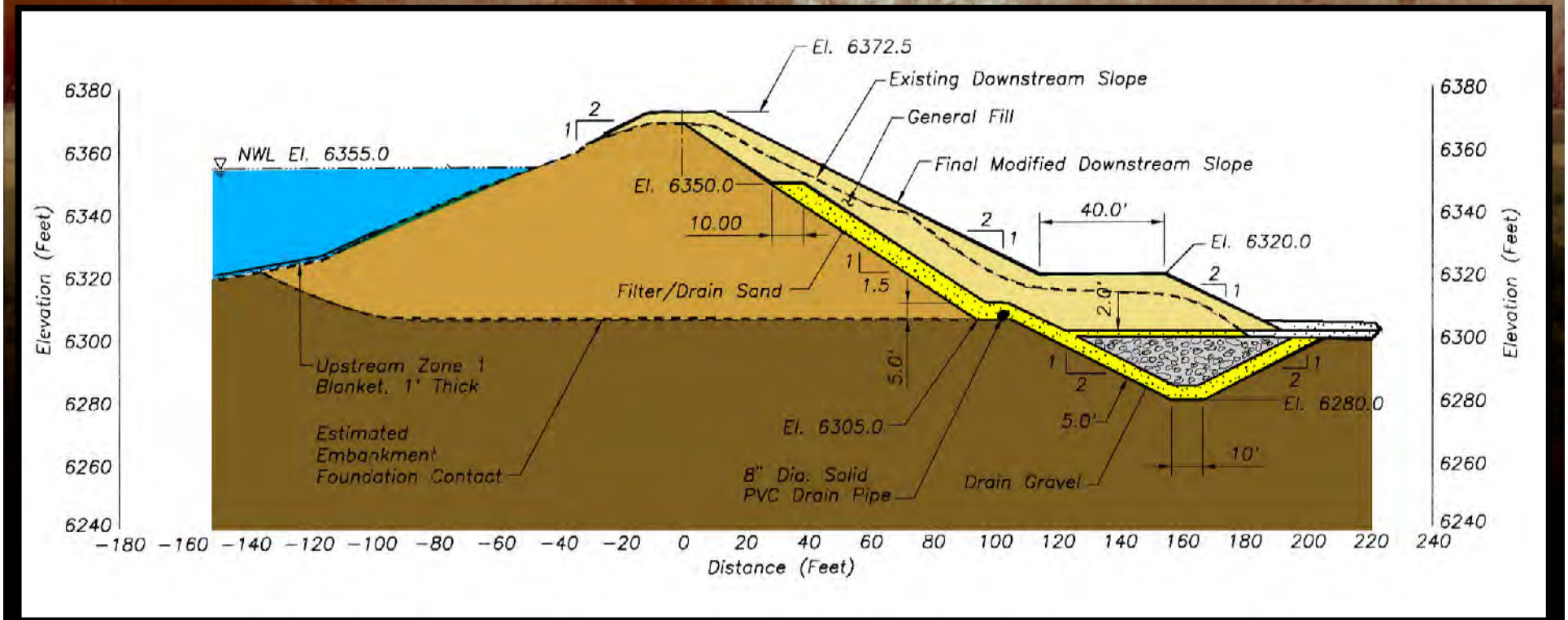
RECOMMENDATIONS

- 3-feet minimum, if placed against an excavated slope
- 5-feet minimum, if placed together with upstream and downstream zones
- Specifications must require prevention of contamination
  - Slope adjacent zones away from filter
  - Maintain filter at least 6-inches above adjacent layers

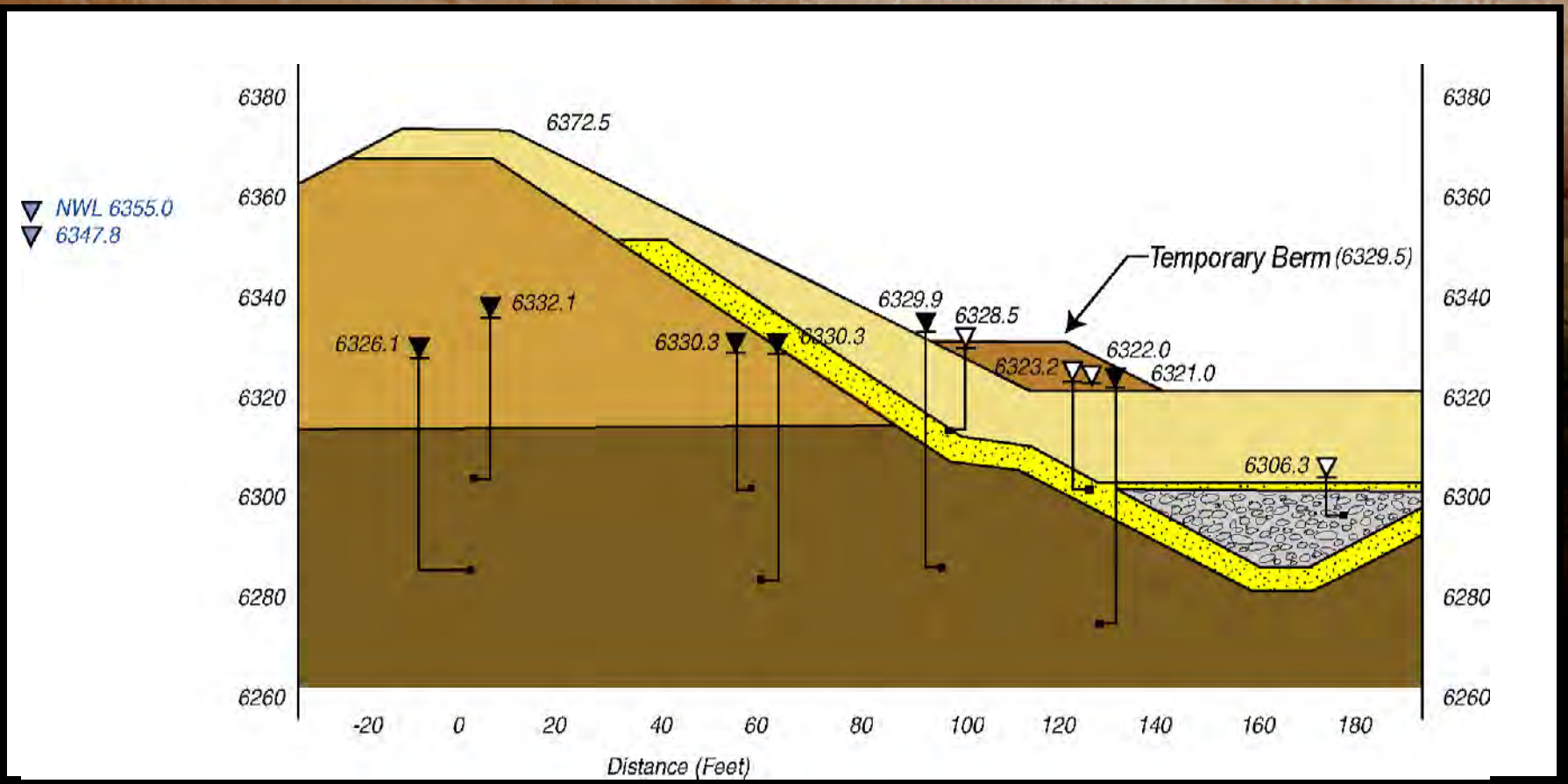
ONE-STAGE VERSUS TWO-STAGE FILTERS

- One-stage filter adequate in most cases for average seepage
- Coarse filter may be needed between sand filter and coarse shell
- Two-stage filter needed, if concentrated seepage is expected

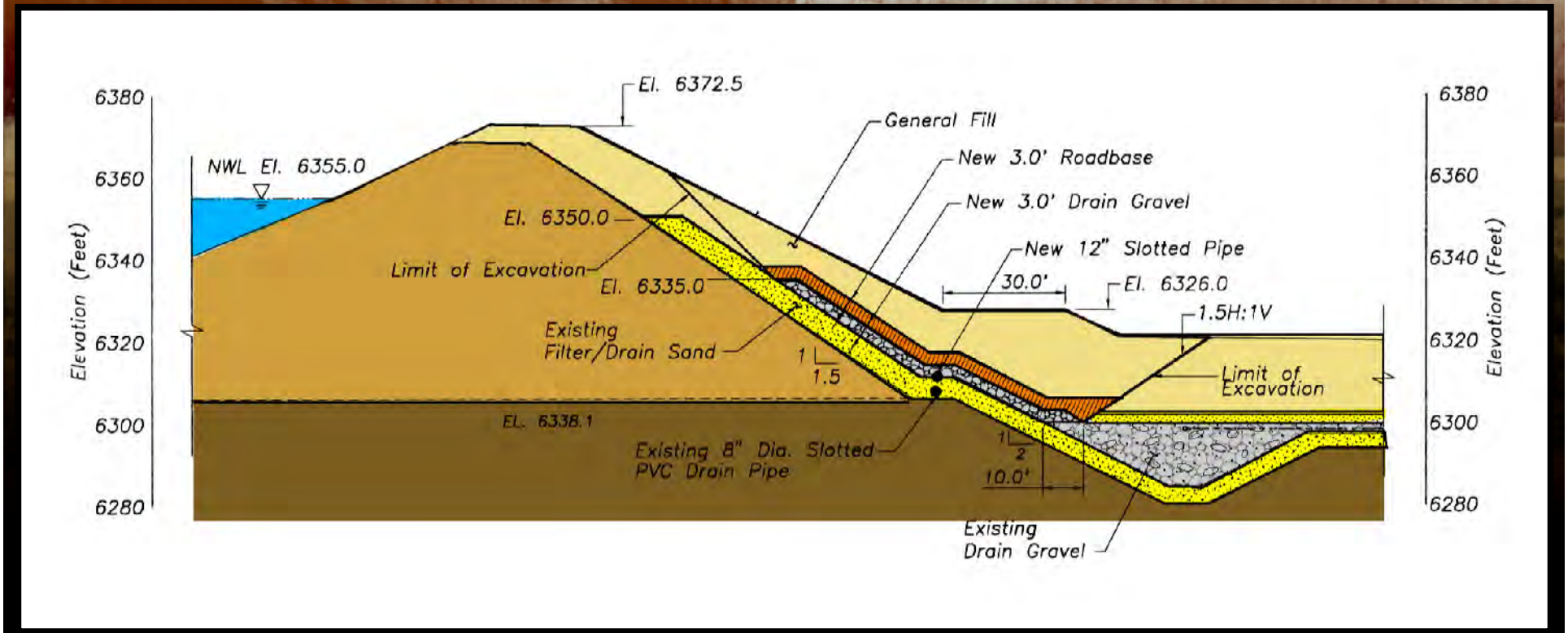
EXAMPLE


El. 6372.5
Existing Downstream Slope
General Fill
Final Modified Downstream Slope
NWL El. 6355.0
El. 6350.0
10.00
40.0'
El. 6320.0
Filter/Drain Sand
1.5
2.0'
5.0'
Upstream Zone 1
Blanket, 1' Thick
Estimated
Embankment
Foundation Contact
El. 6305.0
8" Dia. Solid
PVC Drain Pipe
Drain Gravel
5.0'
10'
El. 6280.0
Elevation (Feet)
Distance (Feet)
6380
6360
6340
6320
6300
6280
6260
6240
−180 −160 −140 −120 −100 −80 −60 −40 −20 0 20 40 60 80 100 120 140 160 180 200 220 240

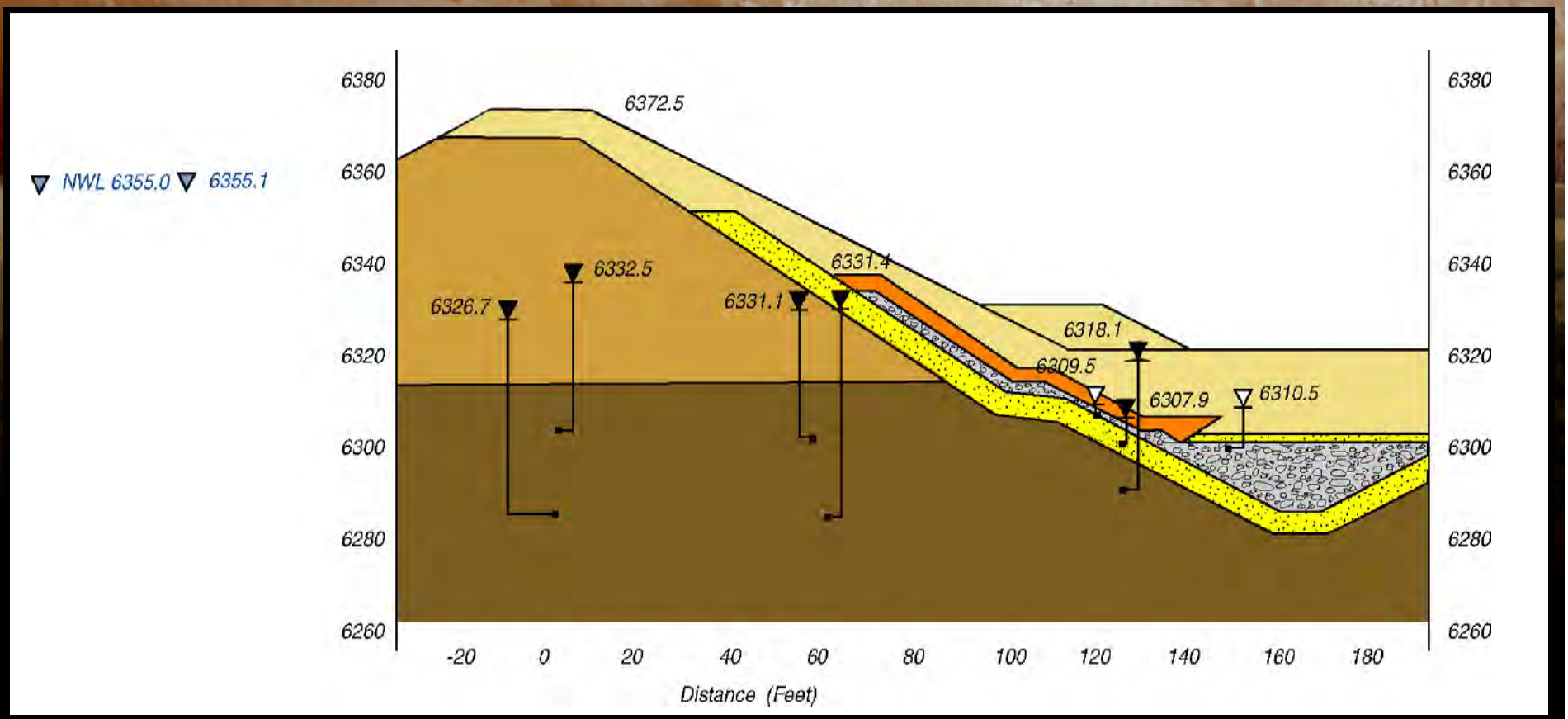
EXAMPLE


NWL 6355.0
6347.8
6380
6360
6340
6320
6300
6280
6260
6372.5
6332.1
6326.1
6330.3
6330.3
6329.9
6328.5
Temporary Berm (6329.5)
6323.2
6322.0
6321.0
6306.3
-20
0
20
40
60
80
100
120
140
160
180
Distance (Feet)

EXAMPLE


El. 6372.5
General Fill
New 3.0' Roadbase
New 3.0' Drain Gravel
NWL El. 6355.0
El. 6350.0
Limit of Excavation
New 12" Slotted Pipe
30.0'
El. 6326.0
El. 6335.0
1.5H:1V
Existing
Filter/Drain Sand
1
1.5
Limit of
Excavation
EL. 6338.1
Existing 8" Dia. Slotted
PVC Drain Pipe
1
2
10.0'
Existing
Drain Gravel
6380
6360
6340
6320
6300
6280
Elevation (Feet)

EXAMPLE


NWL 6355.0
6355.1
6380
6360
6340
6320
6300
6280
6260
6372.5
6332.5
6326.7
6331.1
6331.4
6318.1
6309.5
6307.9
6310.5
-20
0
20
40
60
80
100
120
140
160
180
Distance (Feet)

CLOSING

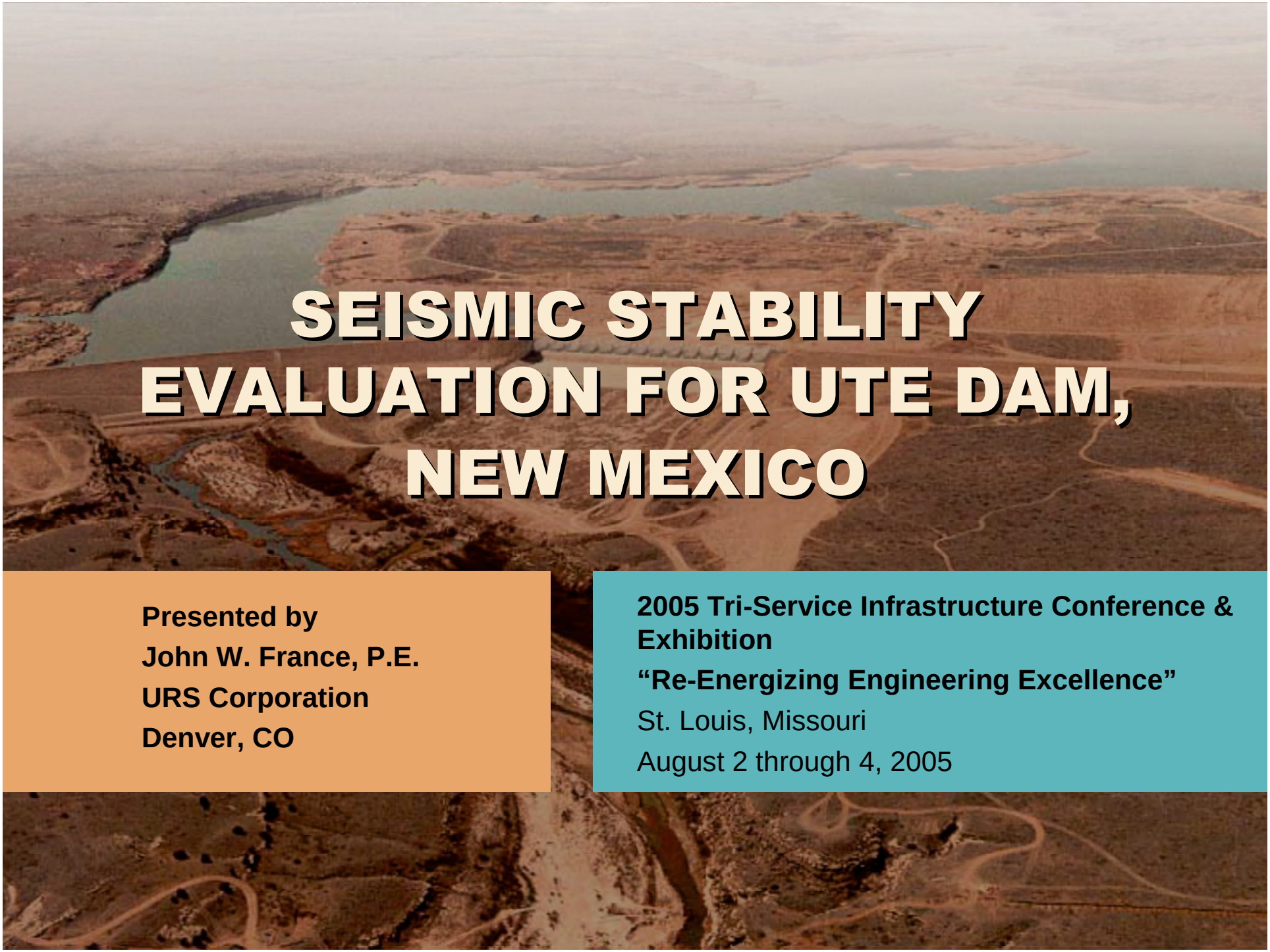
- Several details of seepage collection and control systems have been discussed
- Opinions offered for appropriate treatments
- Seepage collection and control systems will remain a key element of the dam safety engineer’s toolbox
- With appropriate attention to details these systems make dams safer


QUESTIONS?



Contact Information:

John W. France
URS Corporation
Phone: 303-740-3812
email: john_france@urscorp.com



SEISMIC STABILITY EVALUATION FOR UTE DAM, NEW MEXICO

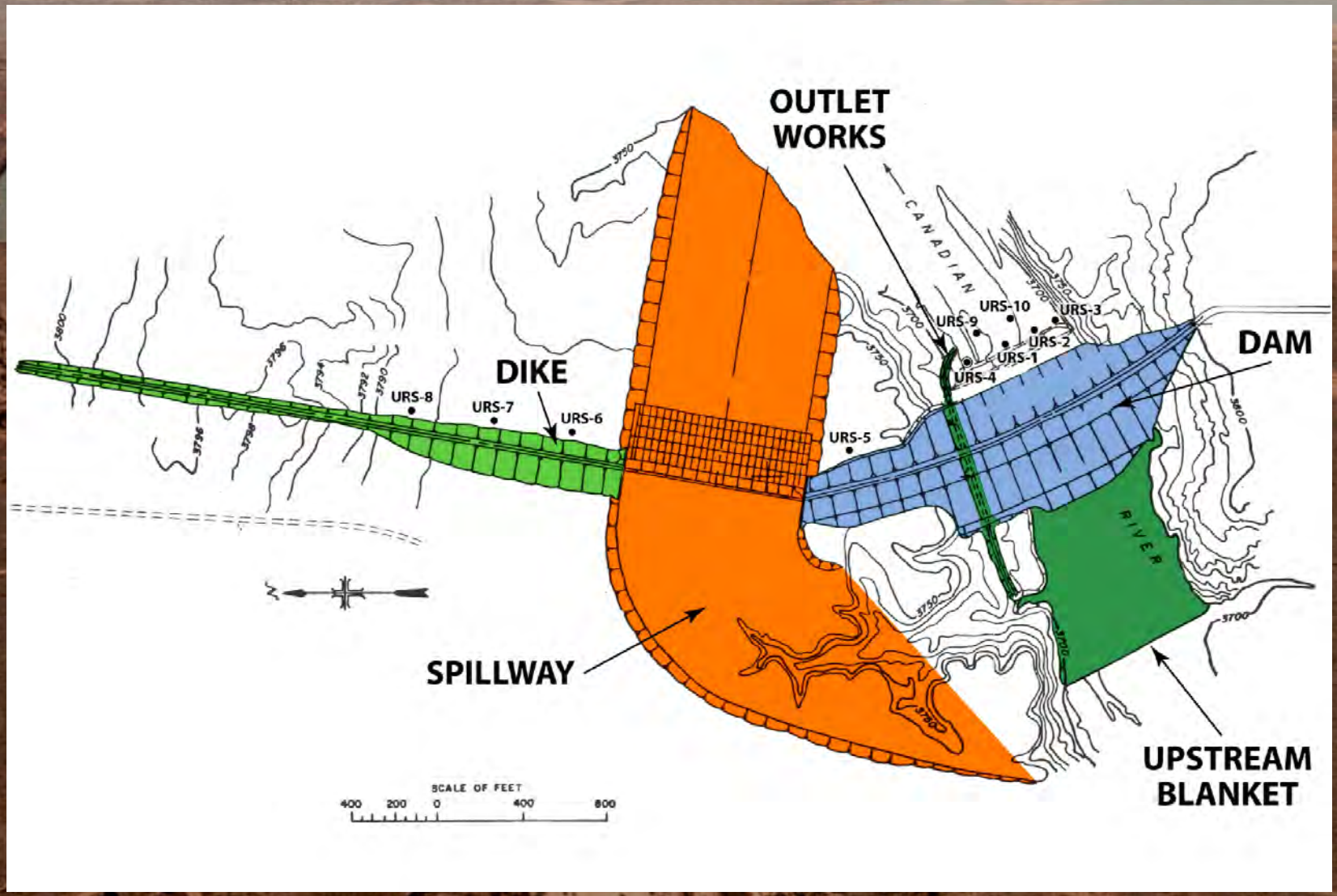
Presented by
John W. France, P.E.
URS Corporation
Denver, CO

2005 Tri-Service Infrastructure Conference & Exhibition
"Re-Energizing Engineering Excellence"
St. Louis, Missouri
August 2 through 4, 2005

PROJECT LOCATION



PROJECT FEATURES



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- Originally constructed 1962-63
- Outlet works modified twice: 1971 and 2000
- Embankment and spillway modified in 1984

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  - crest elevation = 3801
  - crest length = 2,050 ft
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- Concrete ogee crest spillway:
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- Inlet structure on reservoir floor
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- 42-in butterfly valve
- 36-in diameter steel pipe
- Concrete-lined discharge channel

1971 OUTLET WORKS MODIFICATIONS

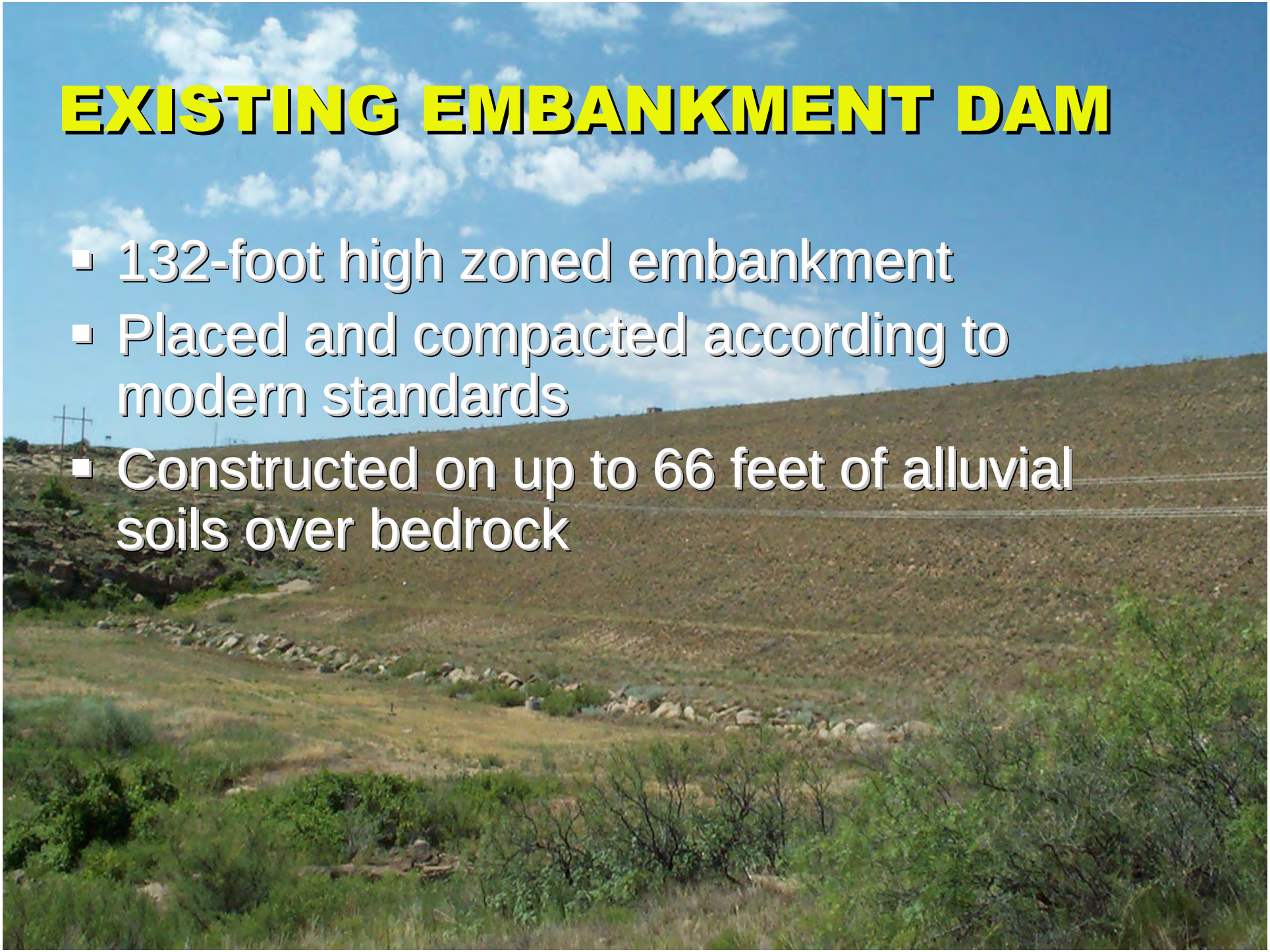
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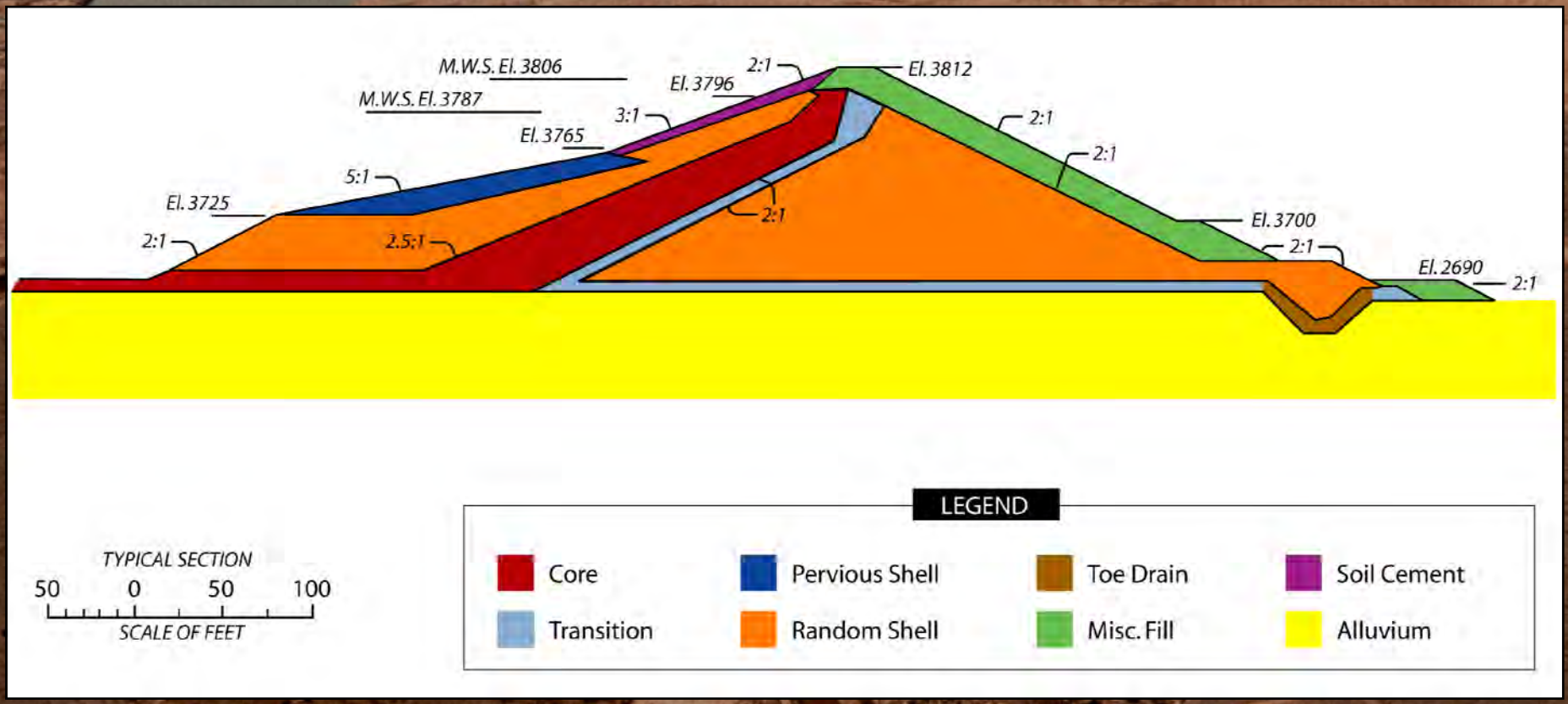
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EMBANKMENT DAM CROSS SECTION





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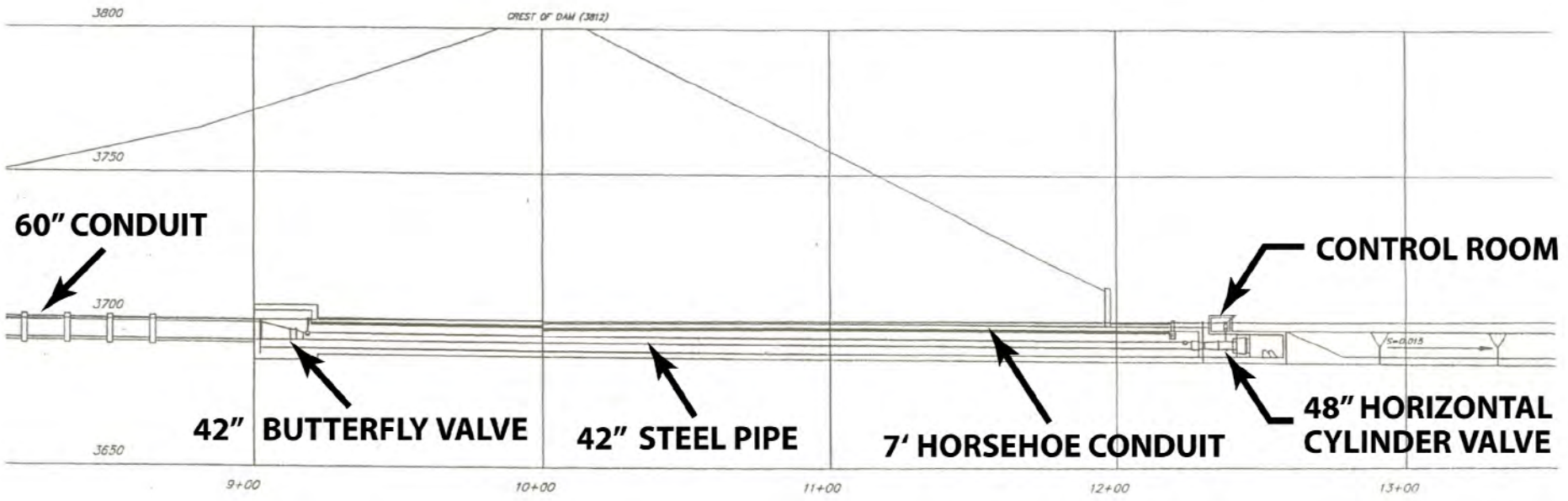
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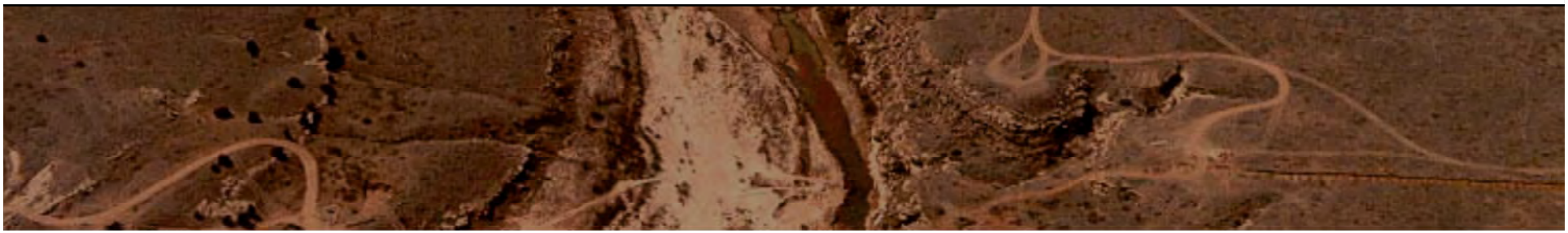


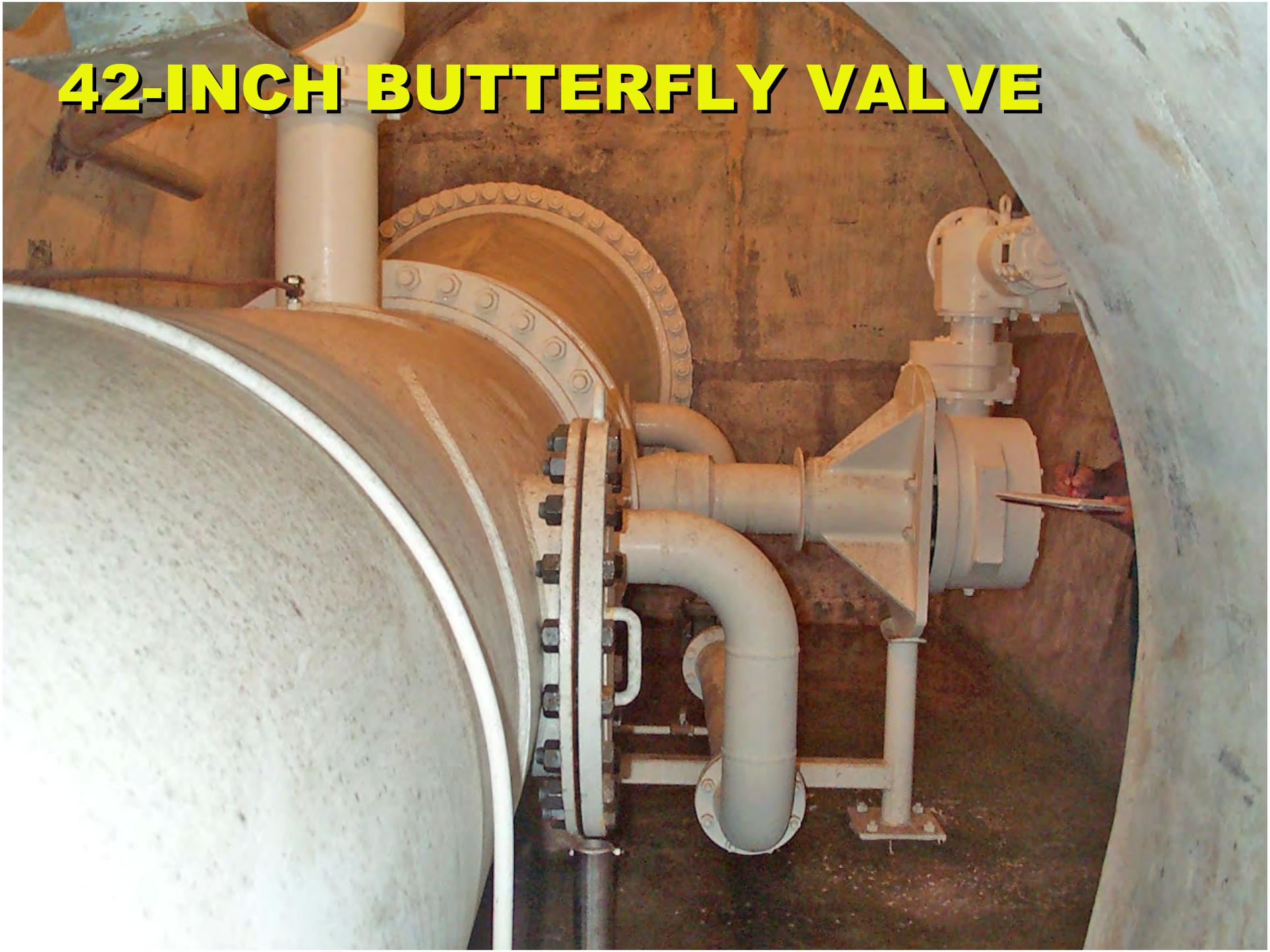
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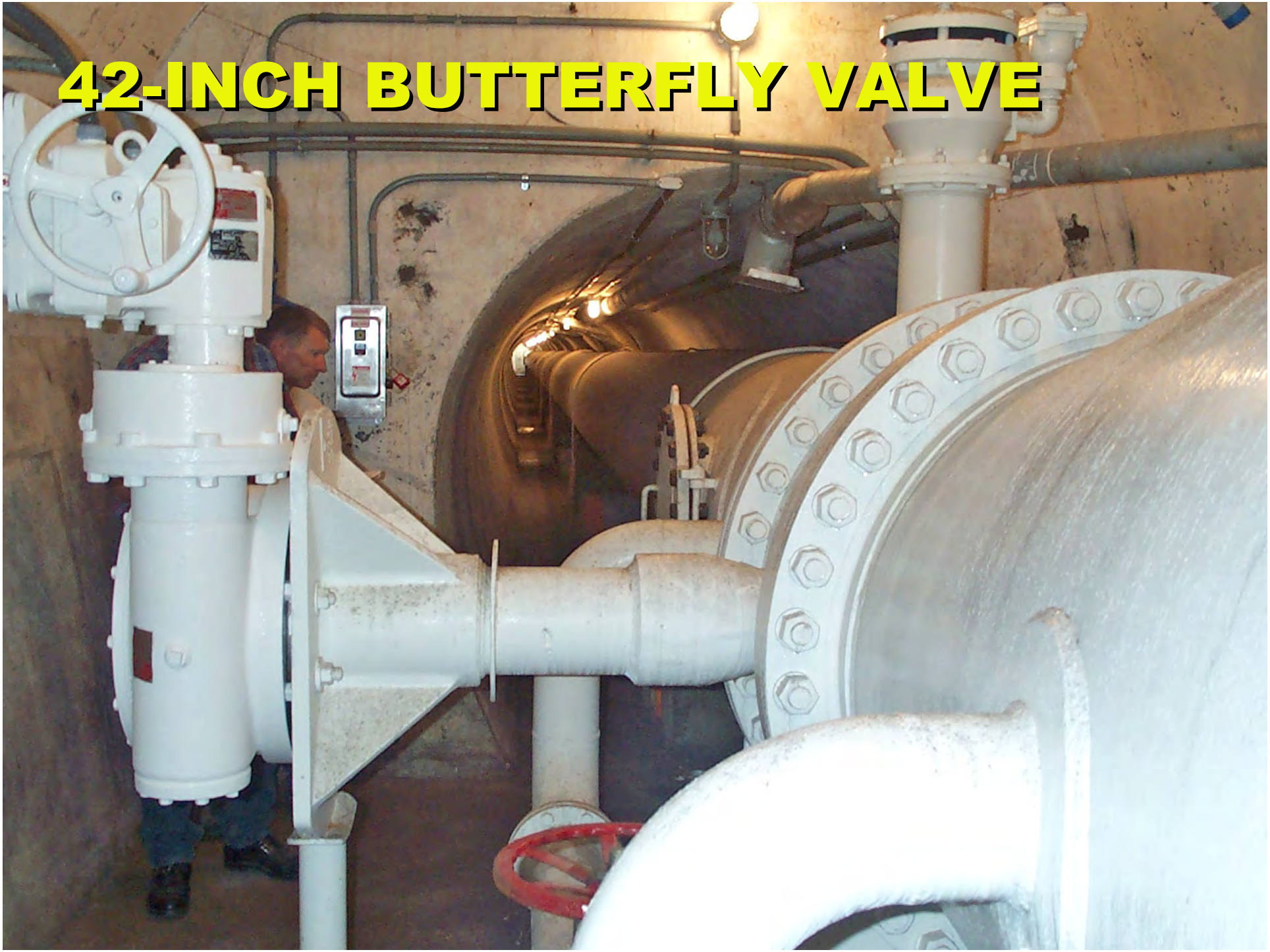
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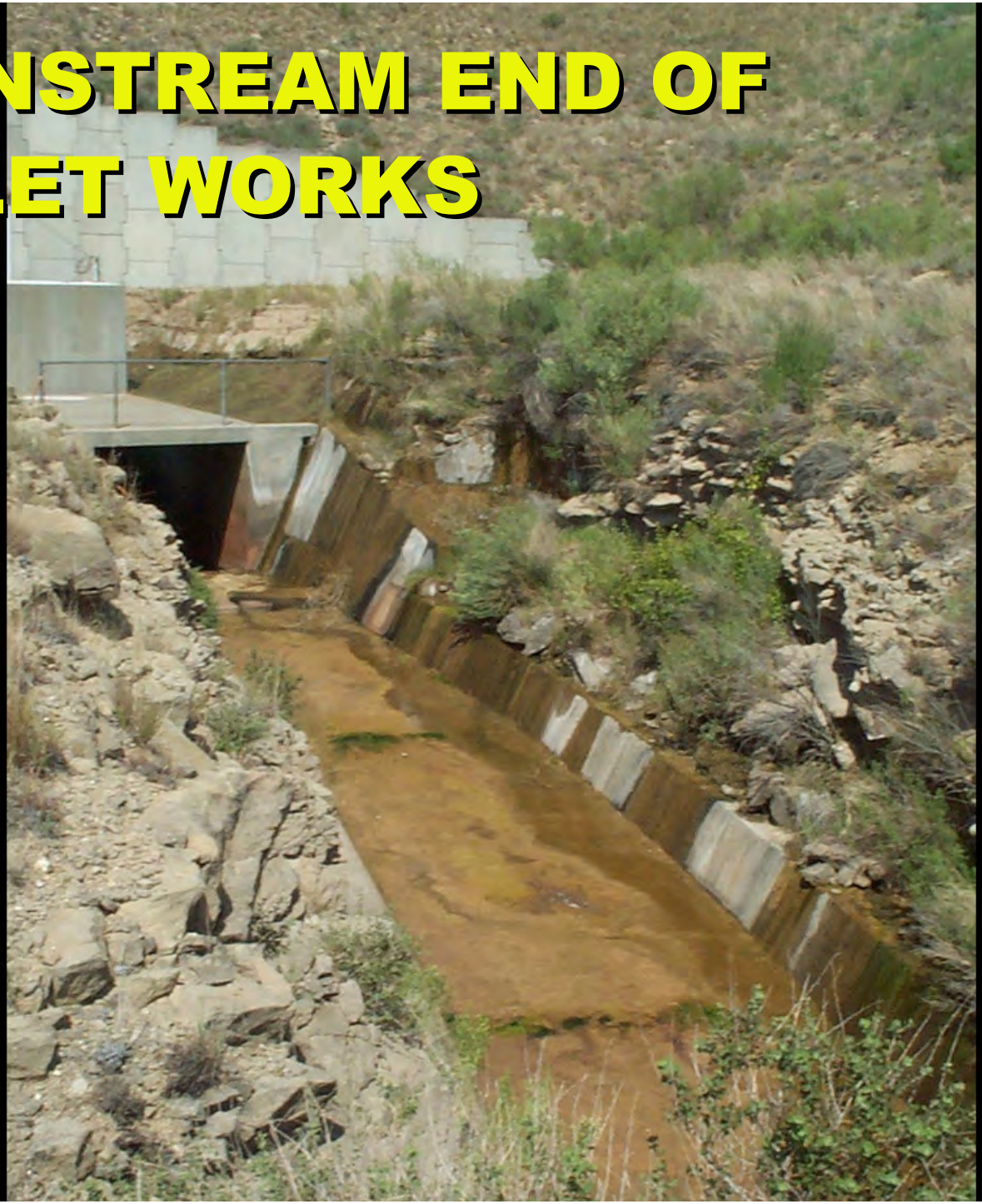



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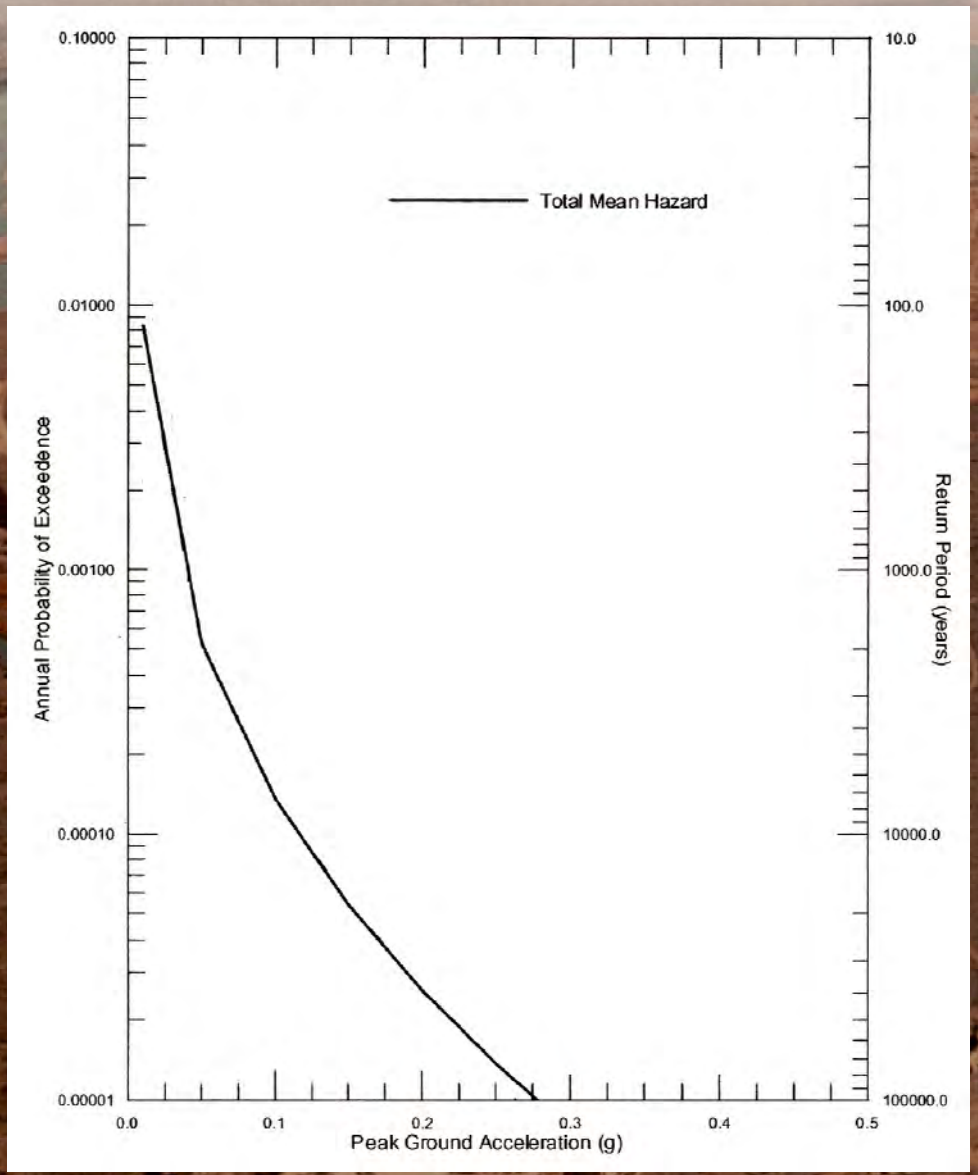
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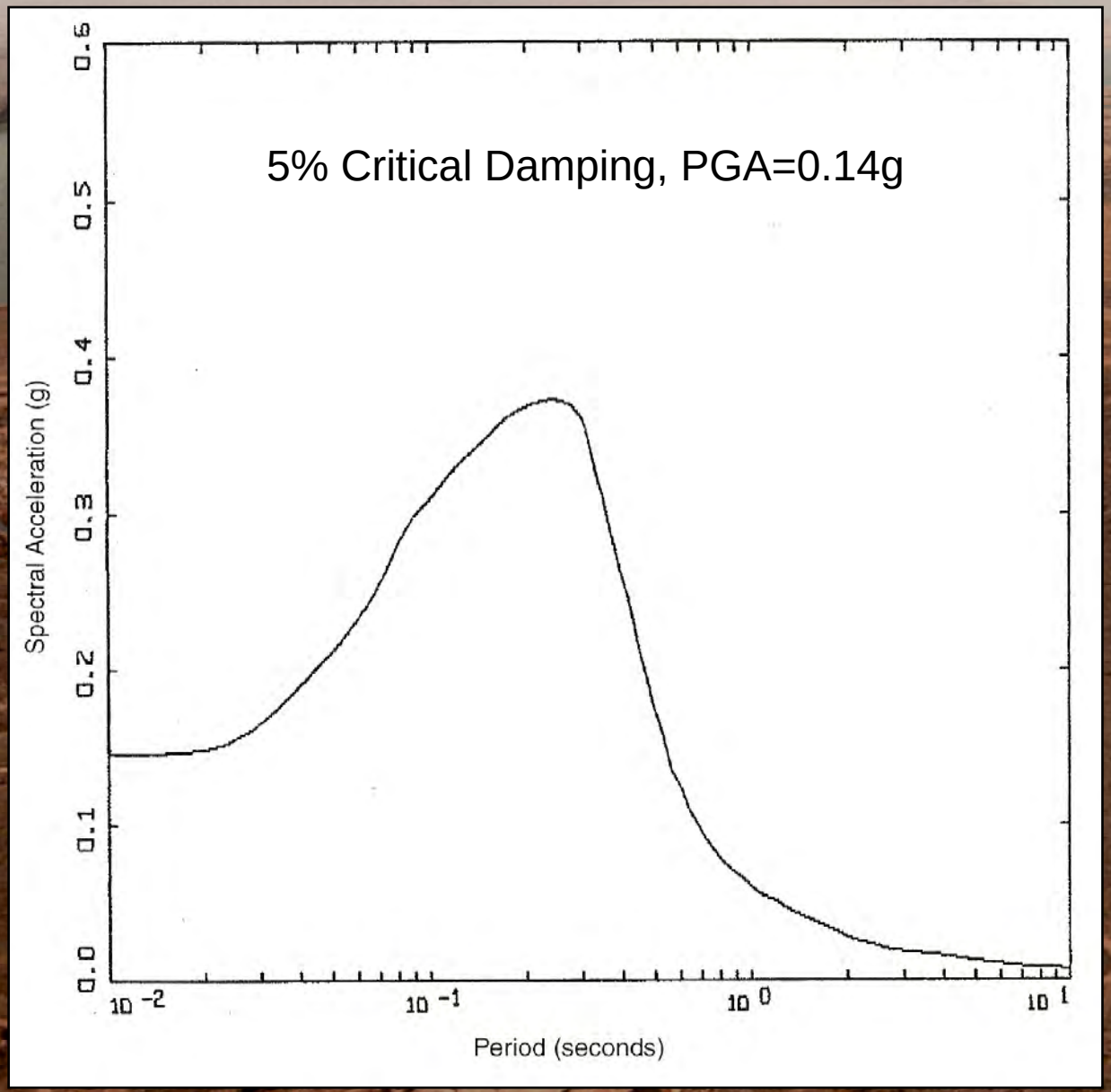
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PSHA – RESPONSE SPECTRA



PSHA – MEAN PEAK GROUND ACCELERATIONS (PGAs)

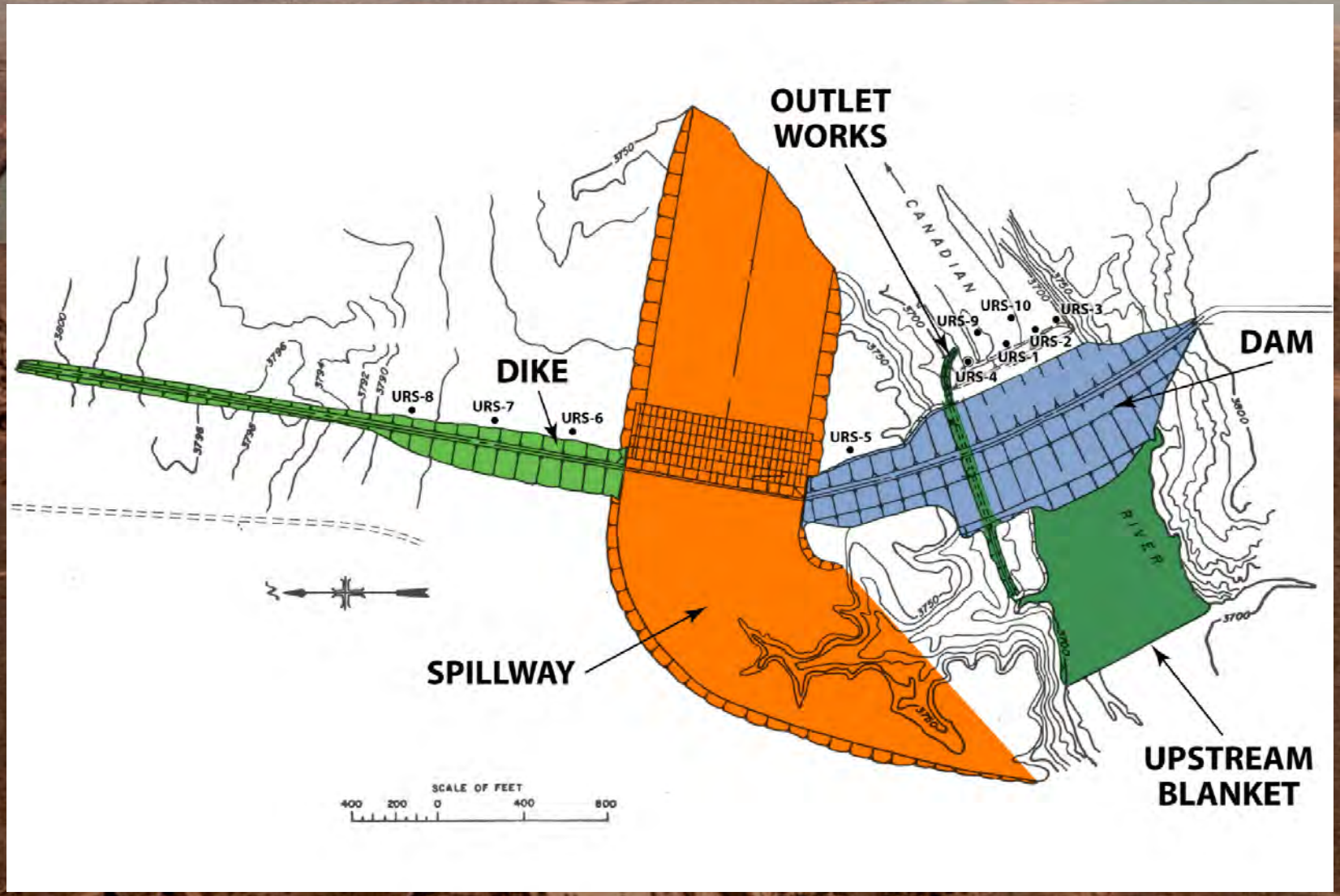
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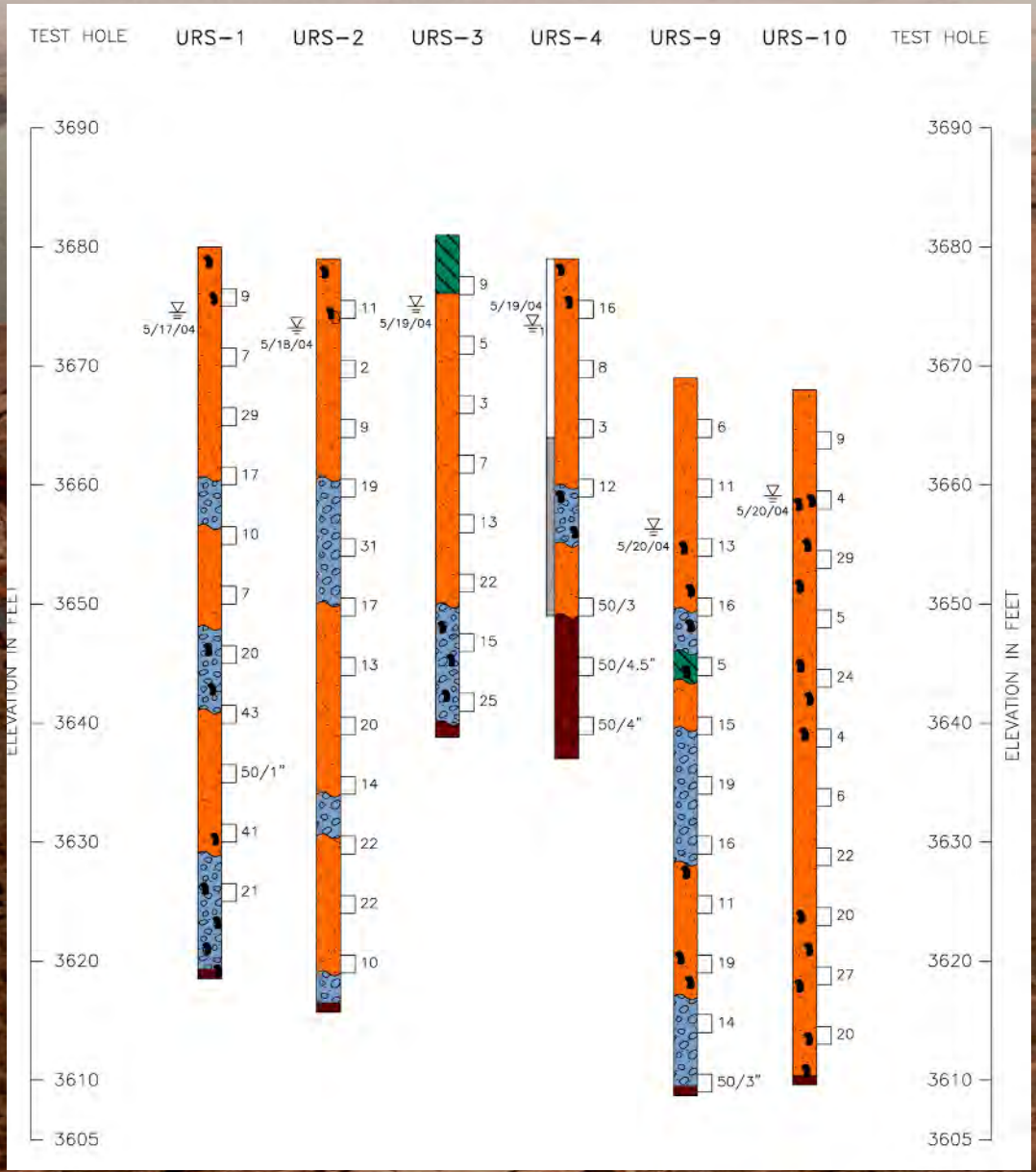
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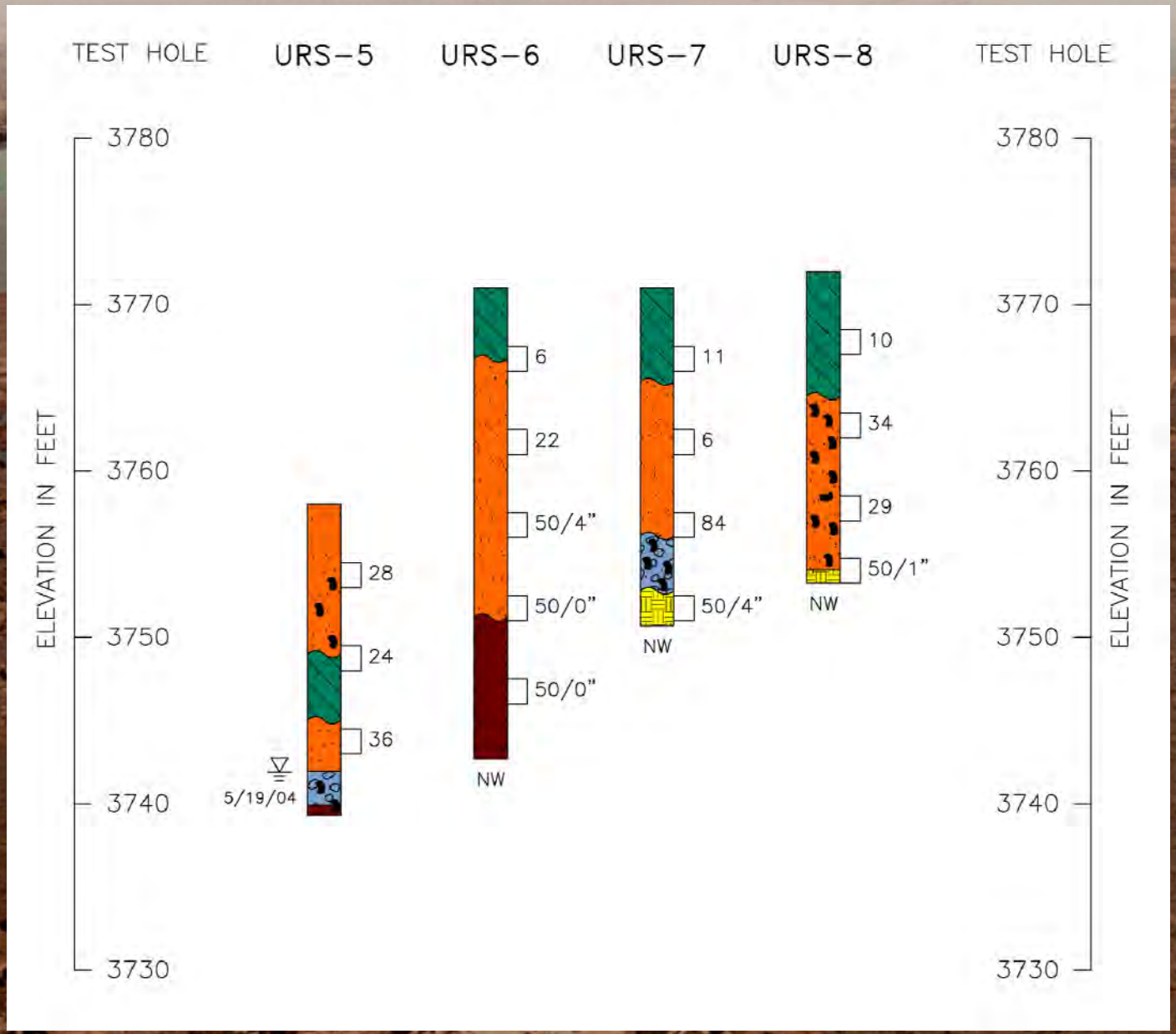
FIELD INVESTIGATIONS



TEST BORINGS - DAM



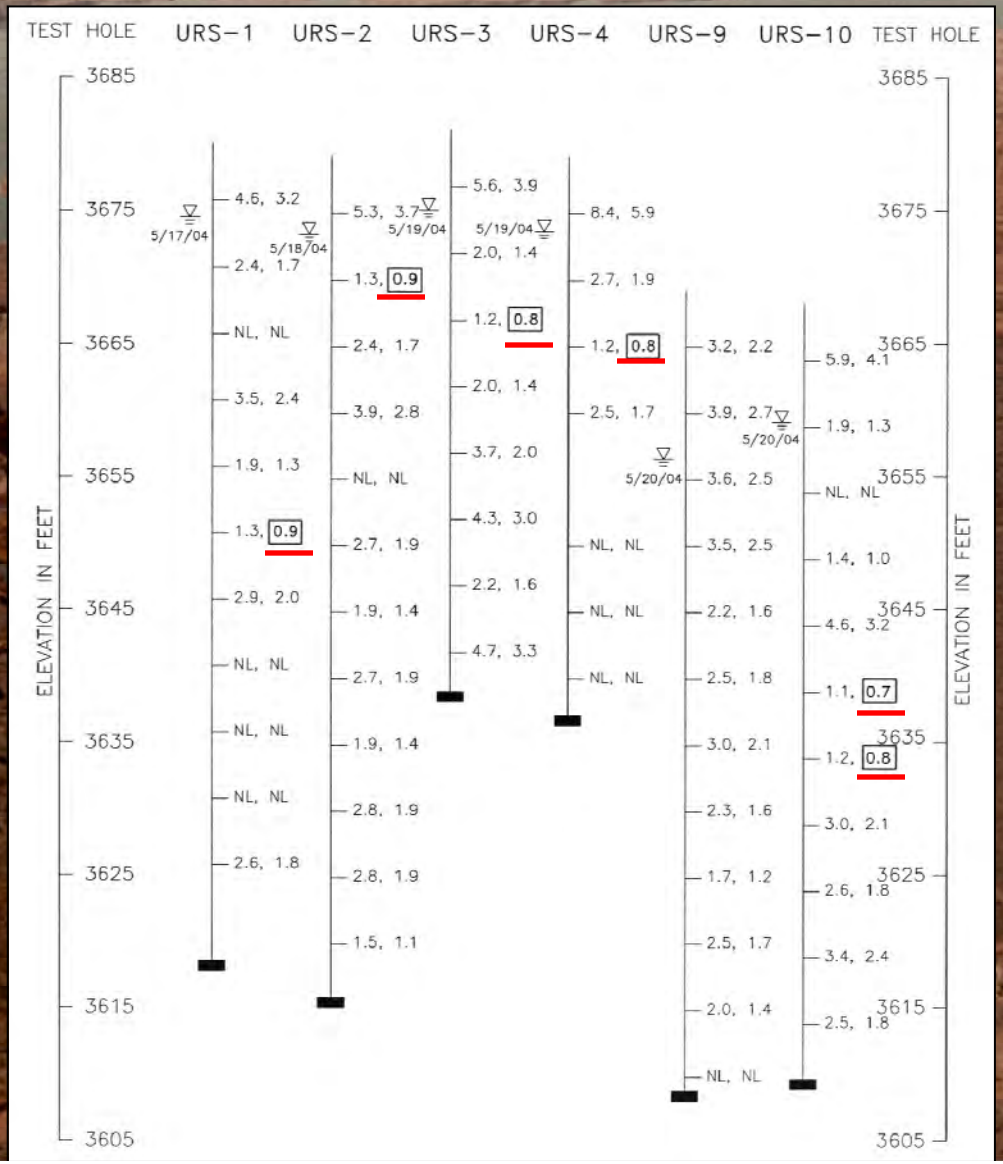
TEST BORINGS - DIKE



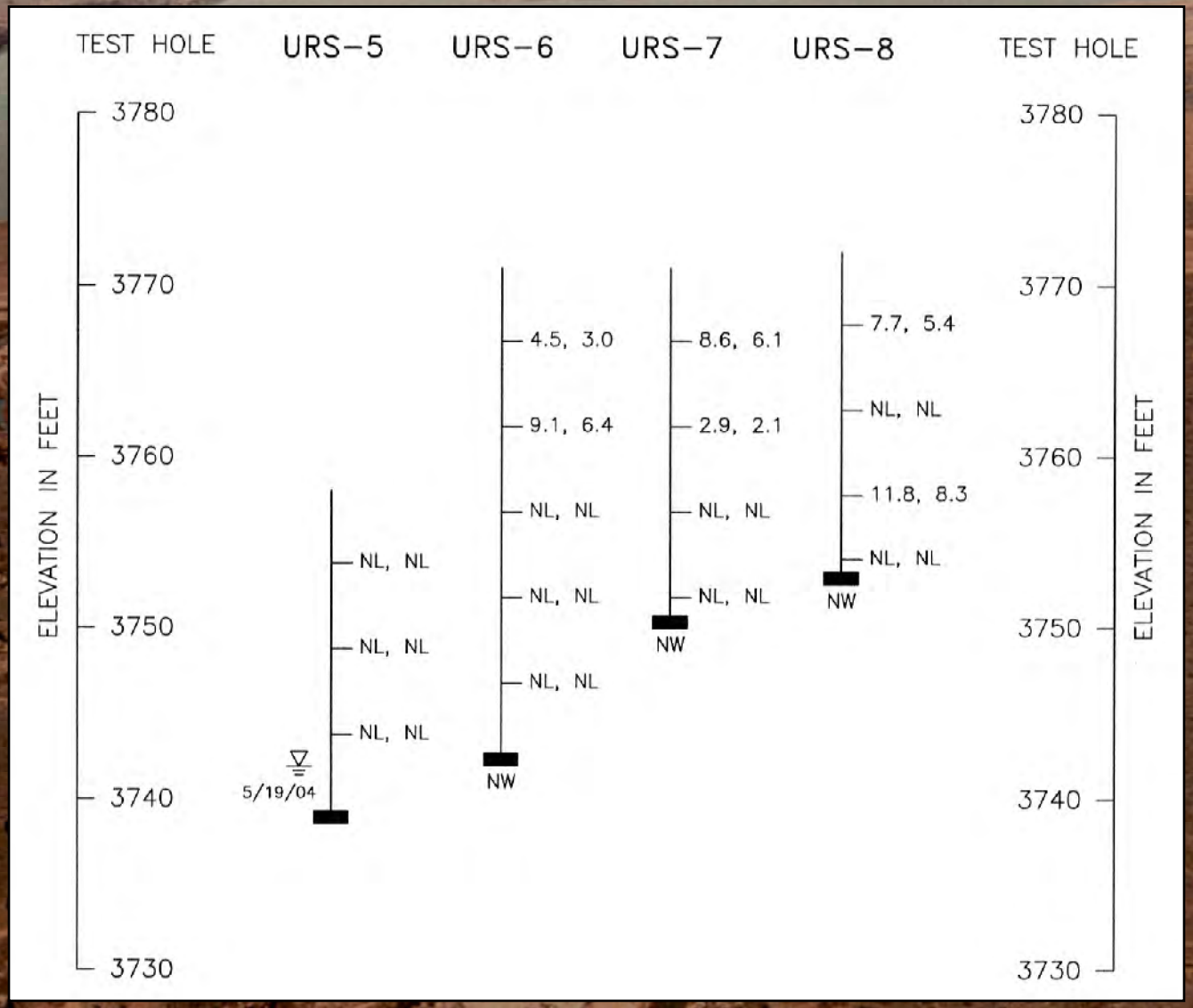
LIQUEFACTION ANALYSIS METHOD

- Procedures based on SPT blowcounts and empirical charts, Youd et al, 2001
- Comparison of cyclic resistance ratio (CRR) with cyclic stress ratio (CSR)
- Analysis included adjustments for:
  - earthquake magnitude
  - fines content
  - overburden pressure
  - depth
  - SPT hammer
- Consideration of gravel effects

LIQUEFACTION ANALYSIS RESULTS – DAM FOUNDATION



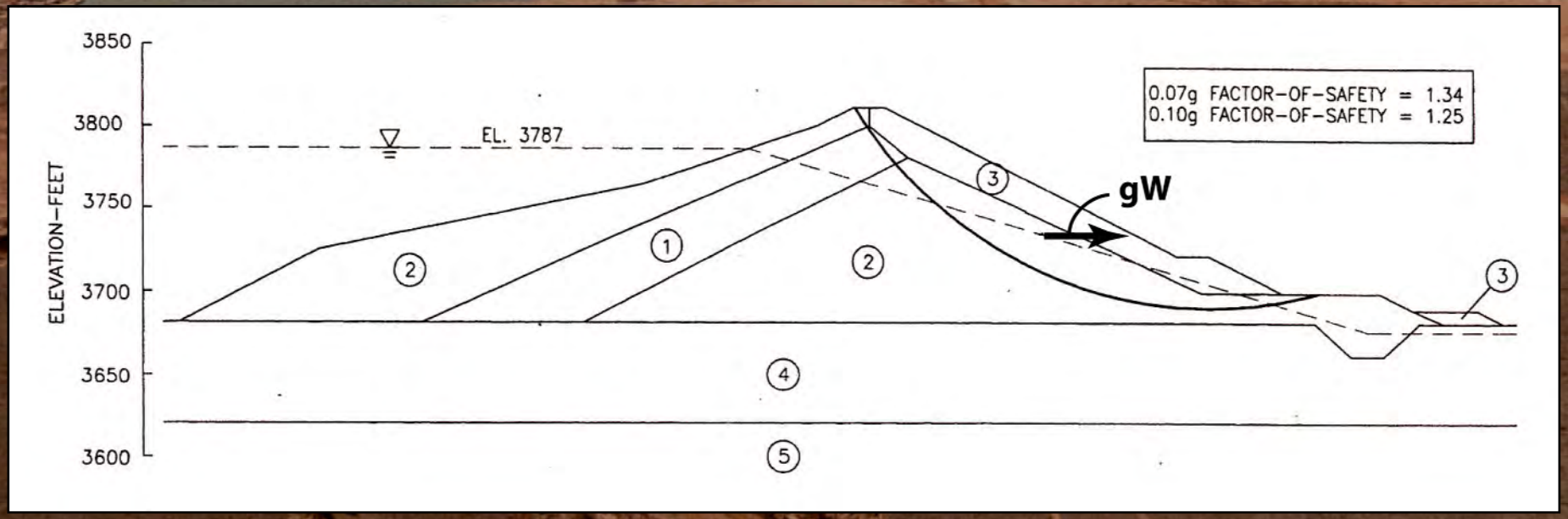
LIQUEFACTION ANALYSIS RESULTS – DIKE FOUNDATION



PSUEDO-STATIC STABILITY ANALYSES

- Psuedo-static coefficients:
  - 5,000 year: 0.07g
  - 10,000 year: 0.10g
- 50% of alluvium PGAs
- NMOSE requires “50% of bedrock acceleration, but not less than 0.05g”
- Analysis coefficients are conservative

EXAMPLE P-S STABILITY ANALYSES



PSUEDO-STATIC ANALYSIS RESULTS

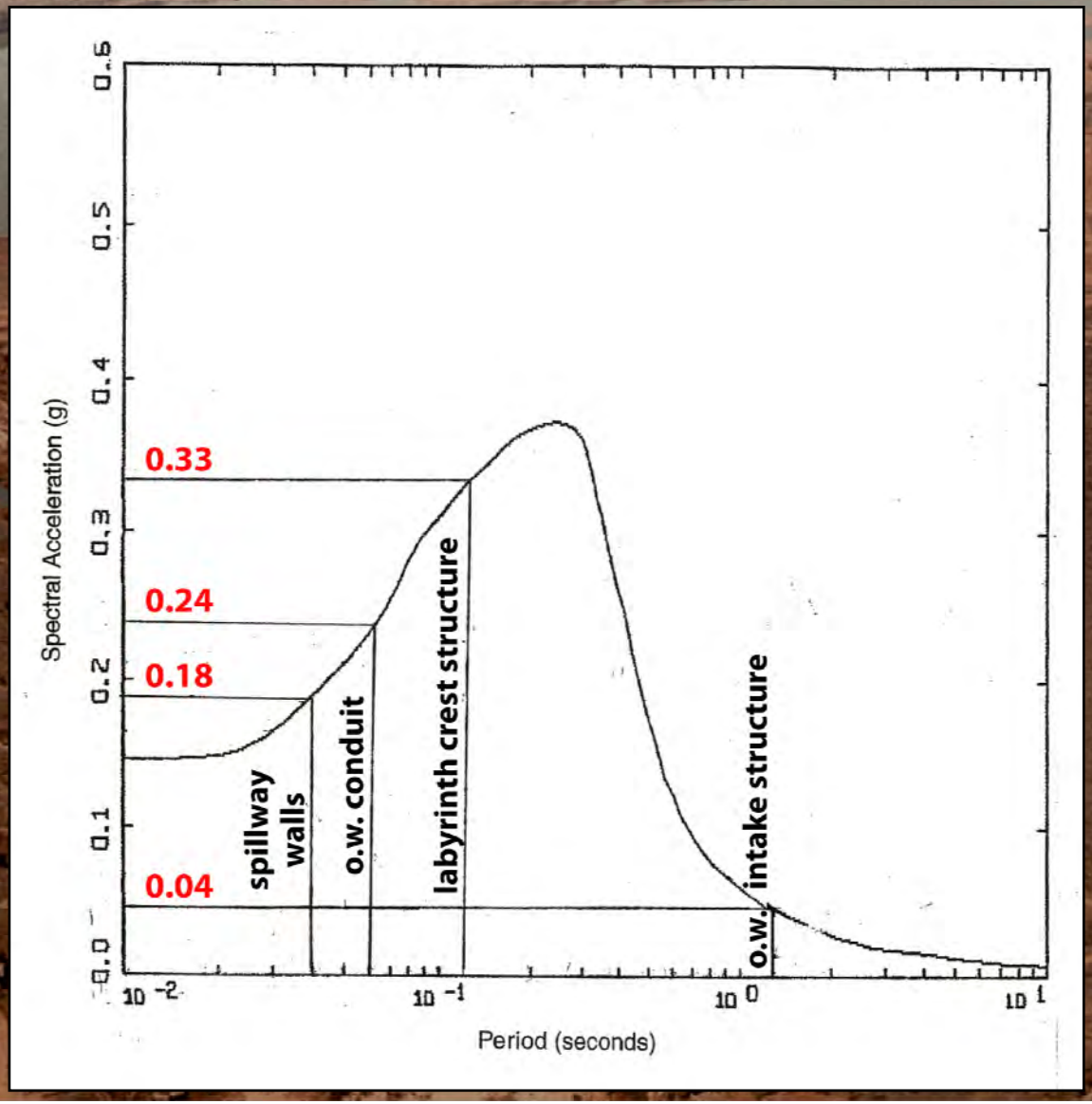
Case	Calculated Factors of Safety	
	5,000 year 0.07g	10,000 year 0.10g
Downstream	1.34 to 1.48	1.25 to 1.36
Upstream	1.77 to 1.85	1.54 to 1.62

NMOSE requires FS $\geq$ 1.1

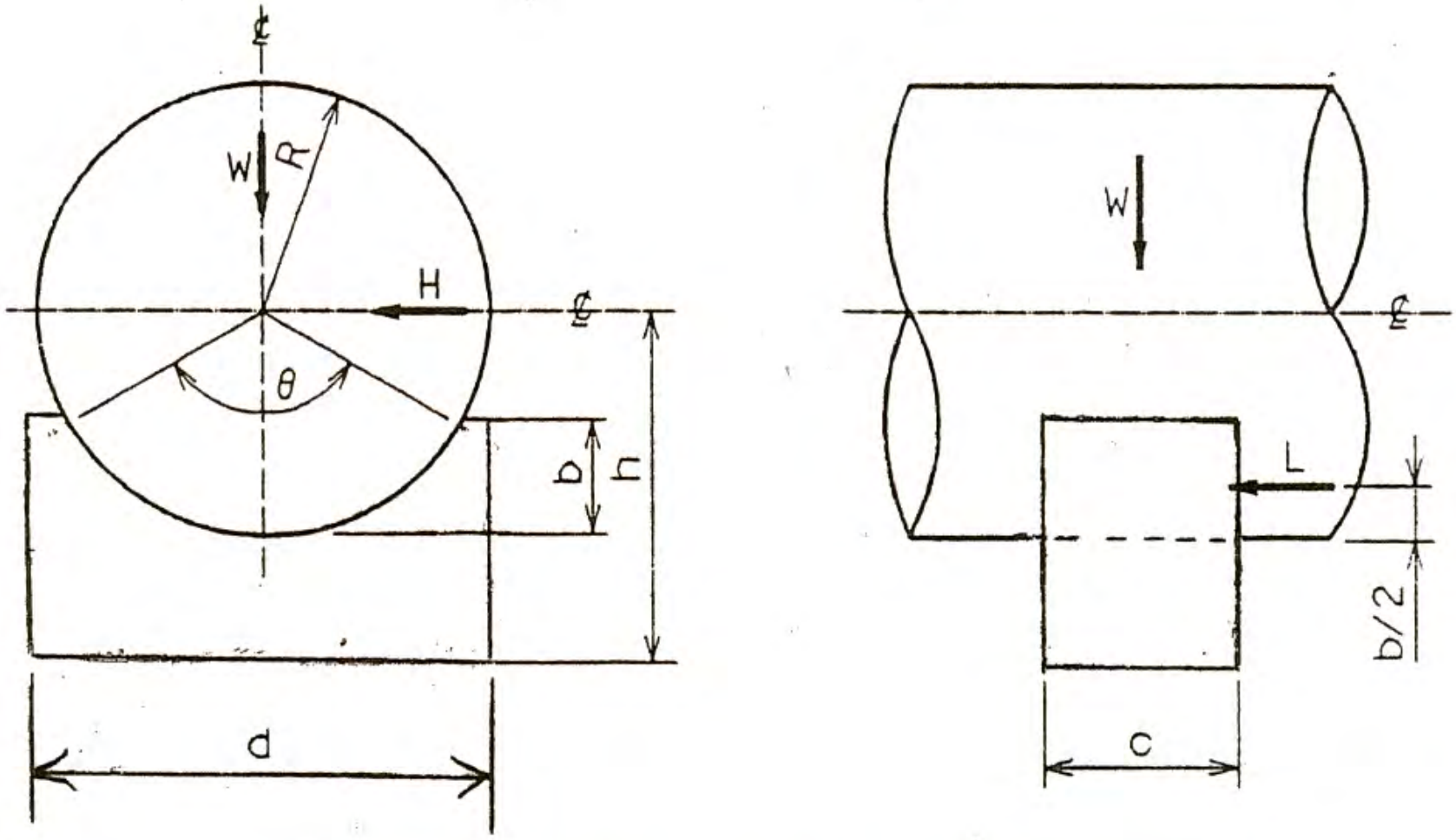
OUTLET WORKS SEISMIC STABILITY ANALYSIS

- Psuedo-dynamic analysis
- EQ load based on response spectrum
- Components analyzed:
  - Intake structure
  - 42-inch steel pipe and saddles
  - Valves
- Components not analyzed:
  - Upstream conduit
  - Horseshoe tunnel

PSHA – RESPONSE SPECTRUM – 5% CRITICAL DAMPING



ILUSTRATION OF METHOD



SADDLE SUPPORT SATBILITY DIAGRAM

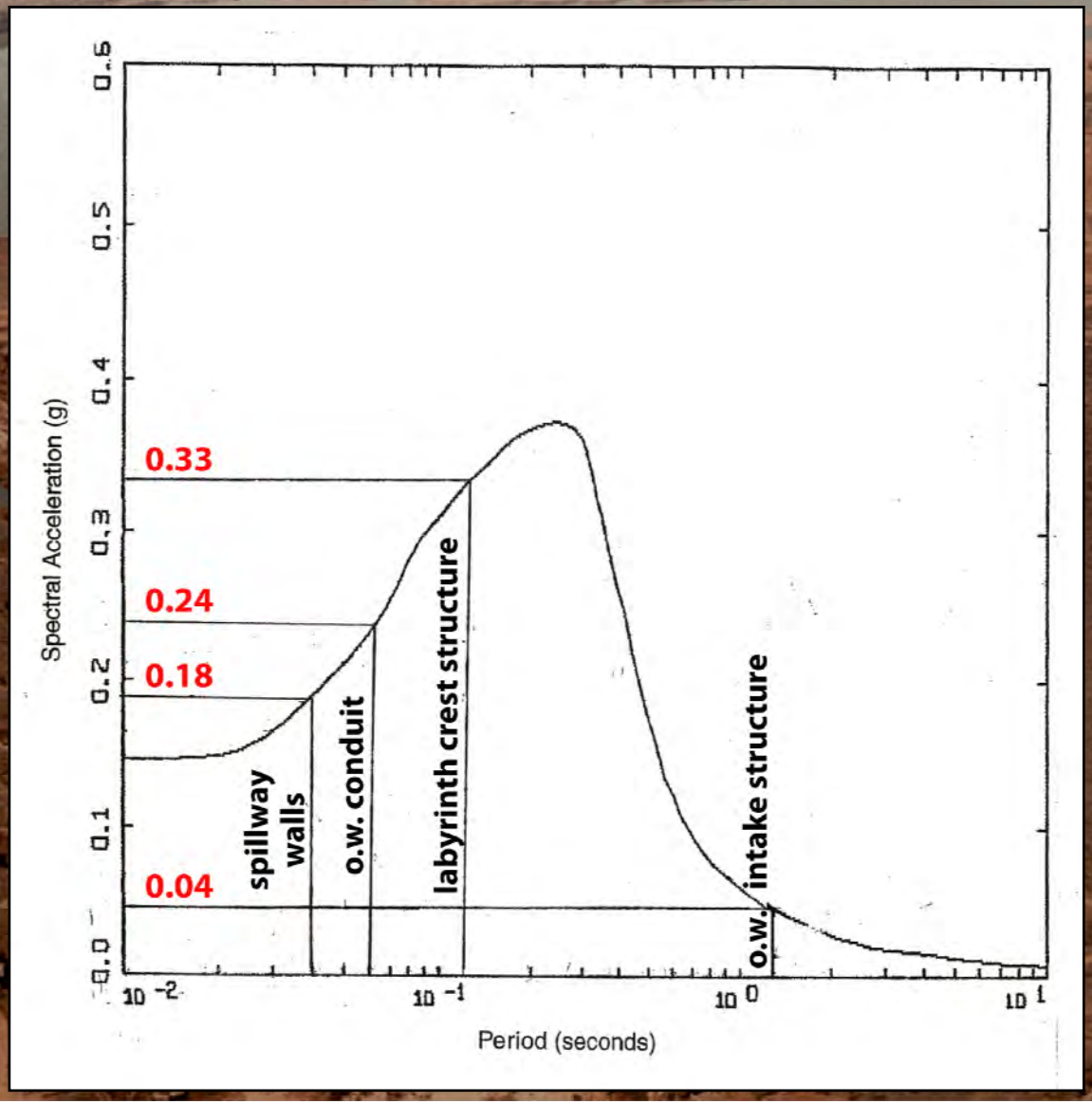
OUTLET WORKS SEISMIC STABILITY ANALYSIS RESULTS

- For all components analyzed:
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  - Calculated stresses are acceptable

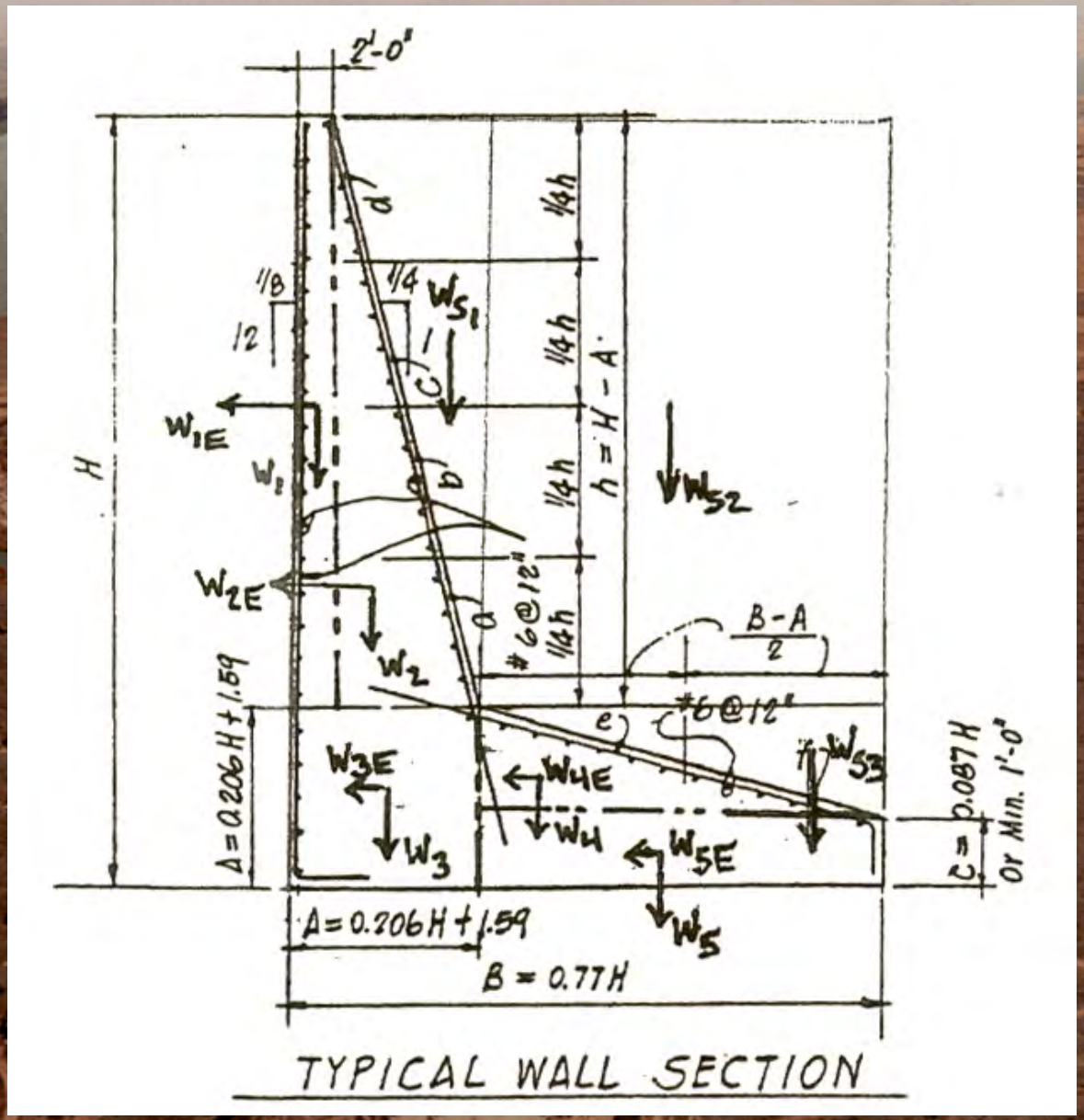
OUTLET WORKS SEISMIC STABILITY ANALYSIS

- Same method of analysis used for outlet works
- Components analyzed:
  - Labyrinth crest structure
  - Spillway gravity side walls
- Components not analyzed:
  - Ogee crest structure
  - Downstream chute

PSHA – RESPONSE SPECTRUM – 5% CRITICAL DAMPING



ILUSTRATION OF METHOD



TYPICAL WALL SECTION

SPILLWAY SEISMIC STABILITY ANALYSIS RESULTS

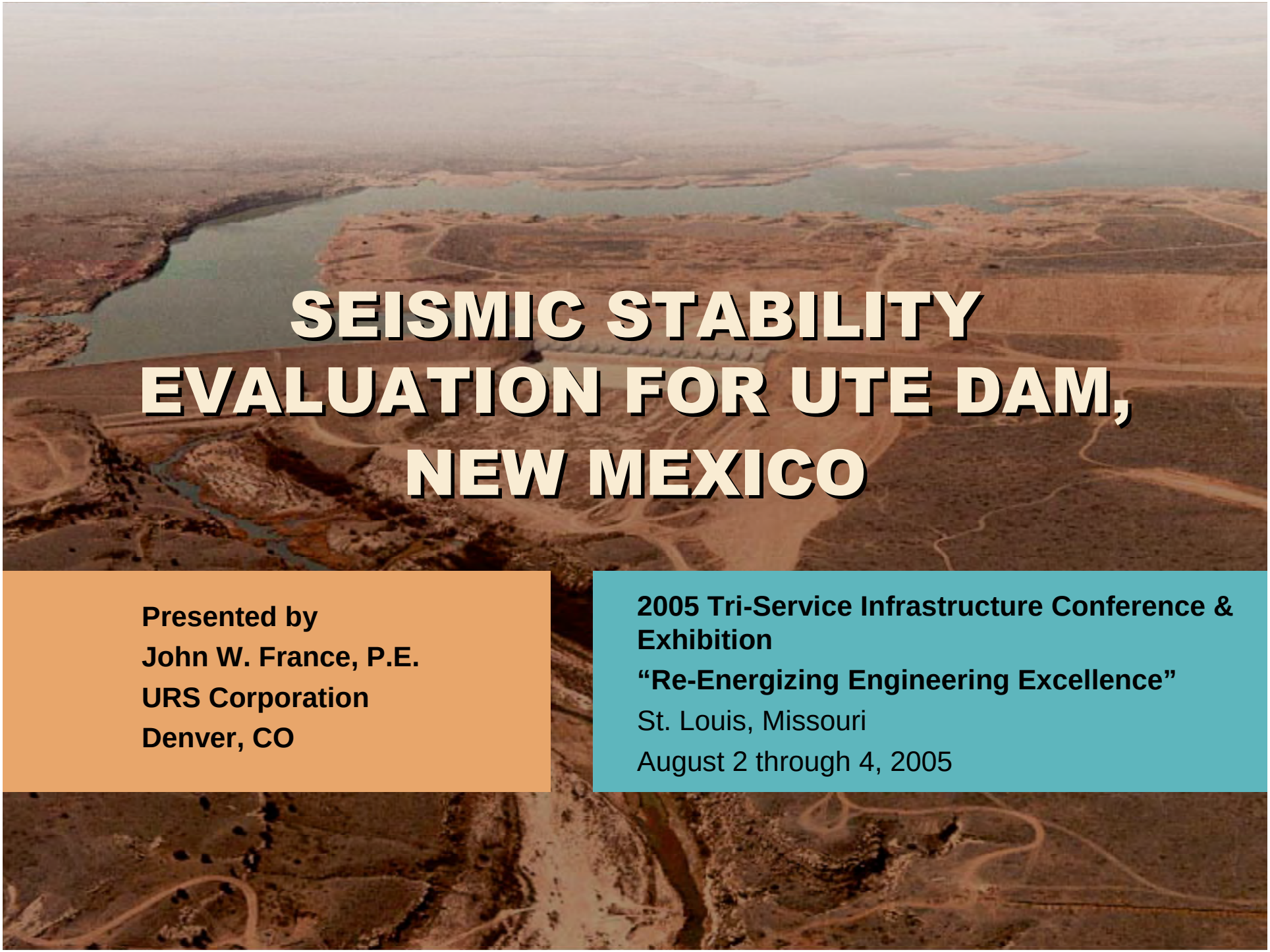
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SUMMARY AND CONCLUSIONS

- Site seismicity is relatively low
- Liquefaction potential judged to be low
- Embankment psuedo-static stability is adequate
- Appurtenant structure expected seismic performance judged to be acceptable
- No remedial action required


QUESTIONS?


Contact Information:
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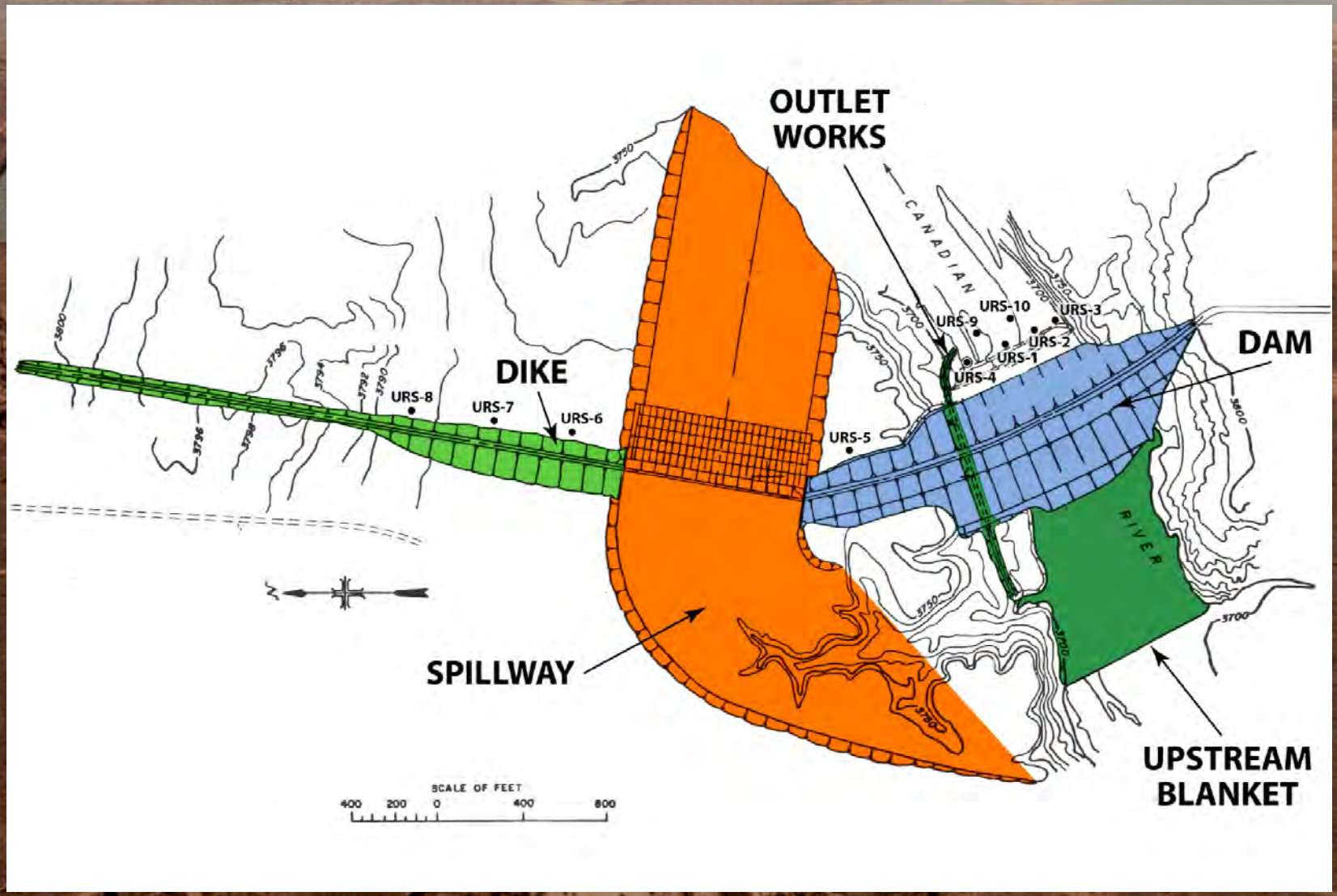
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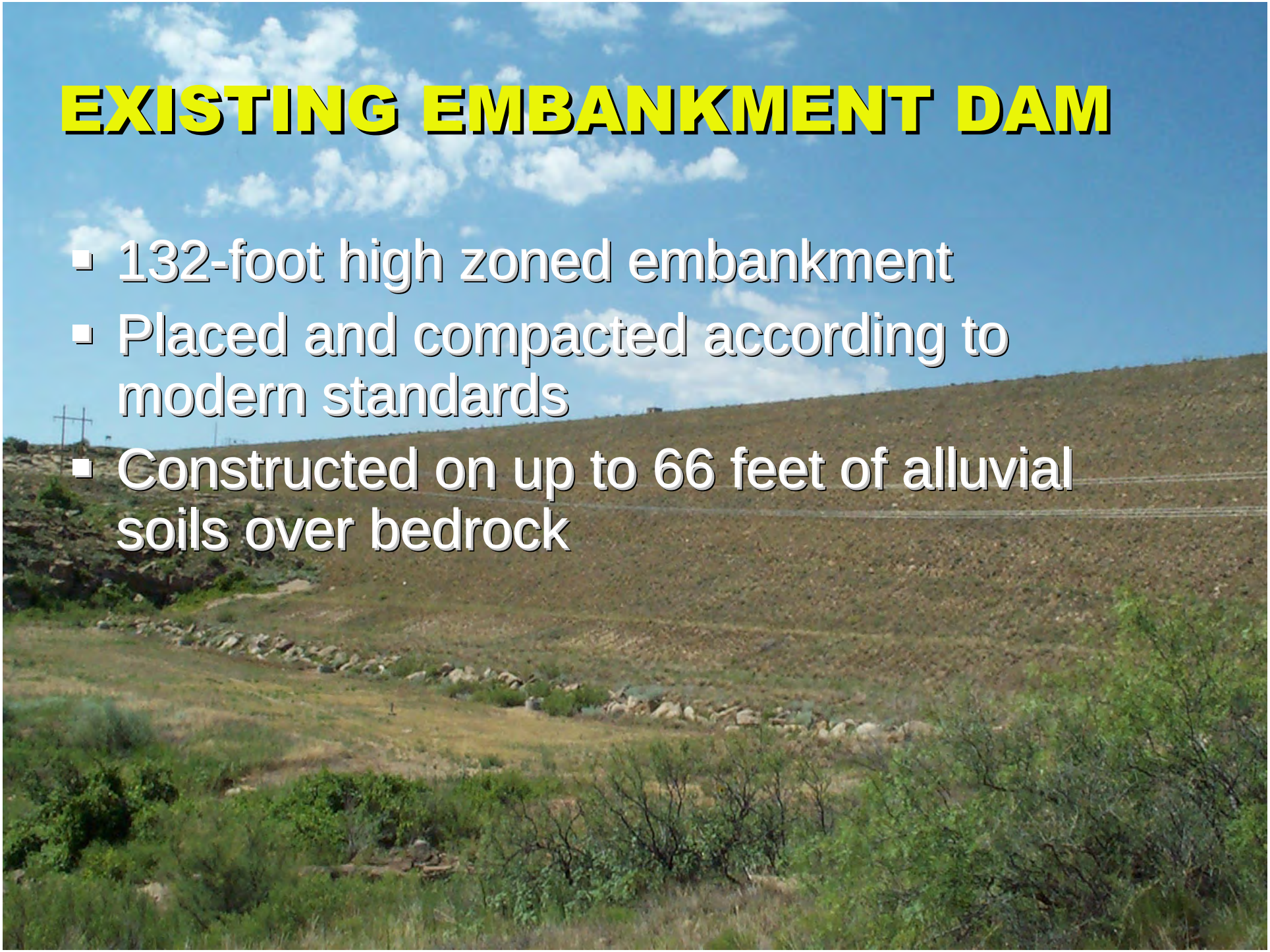
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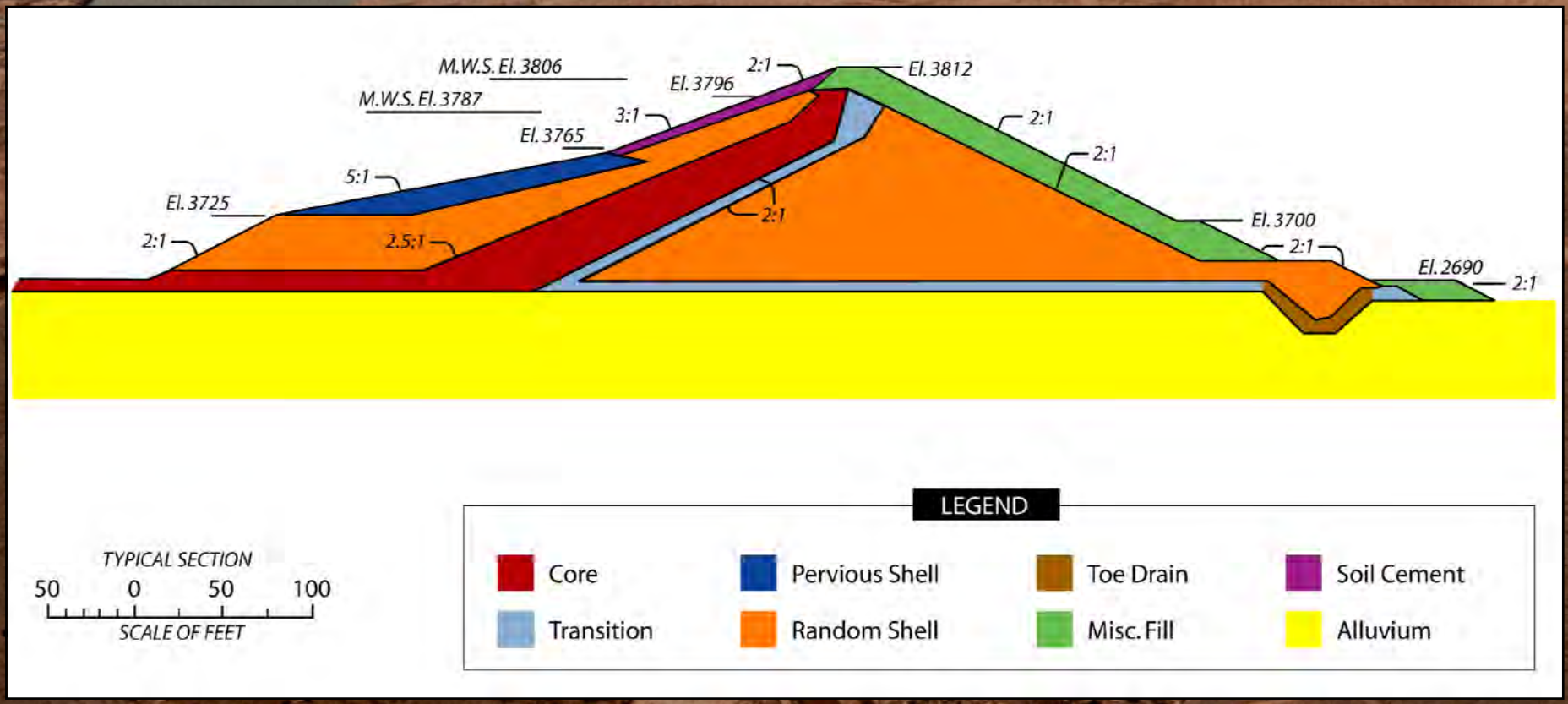
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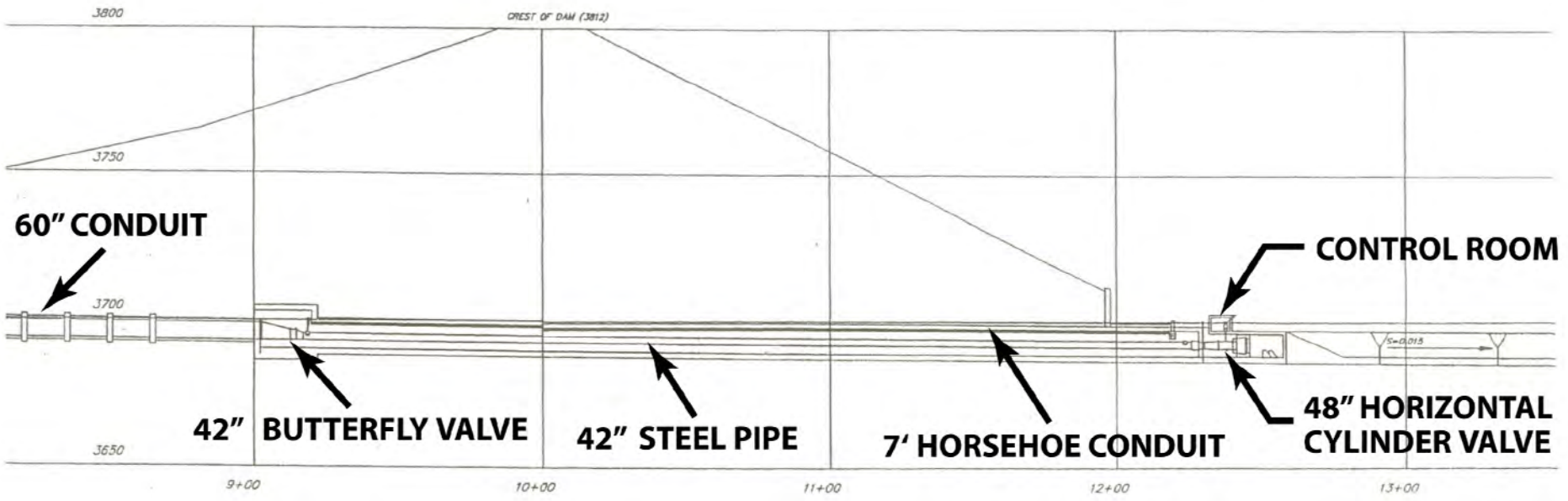
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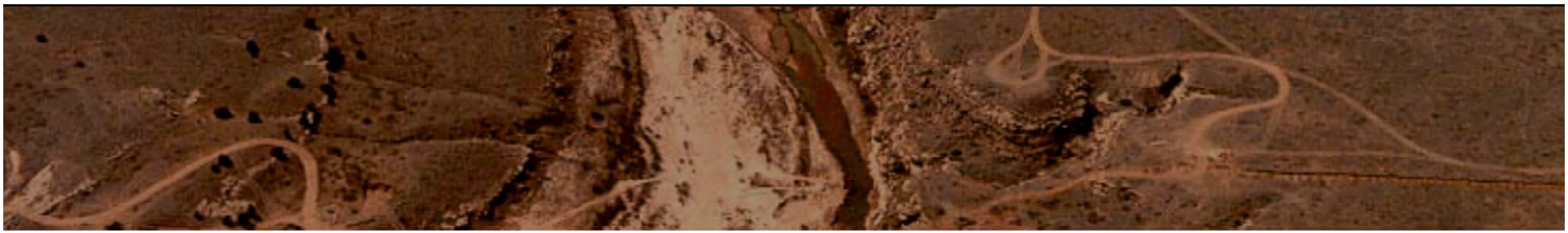


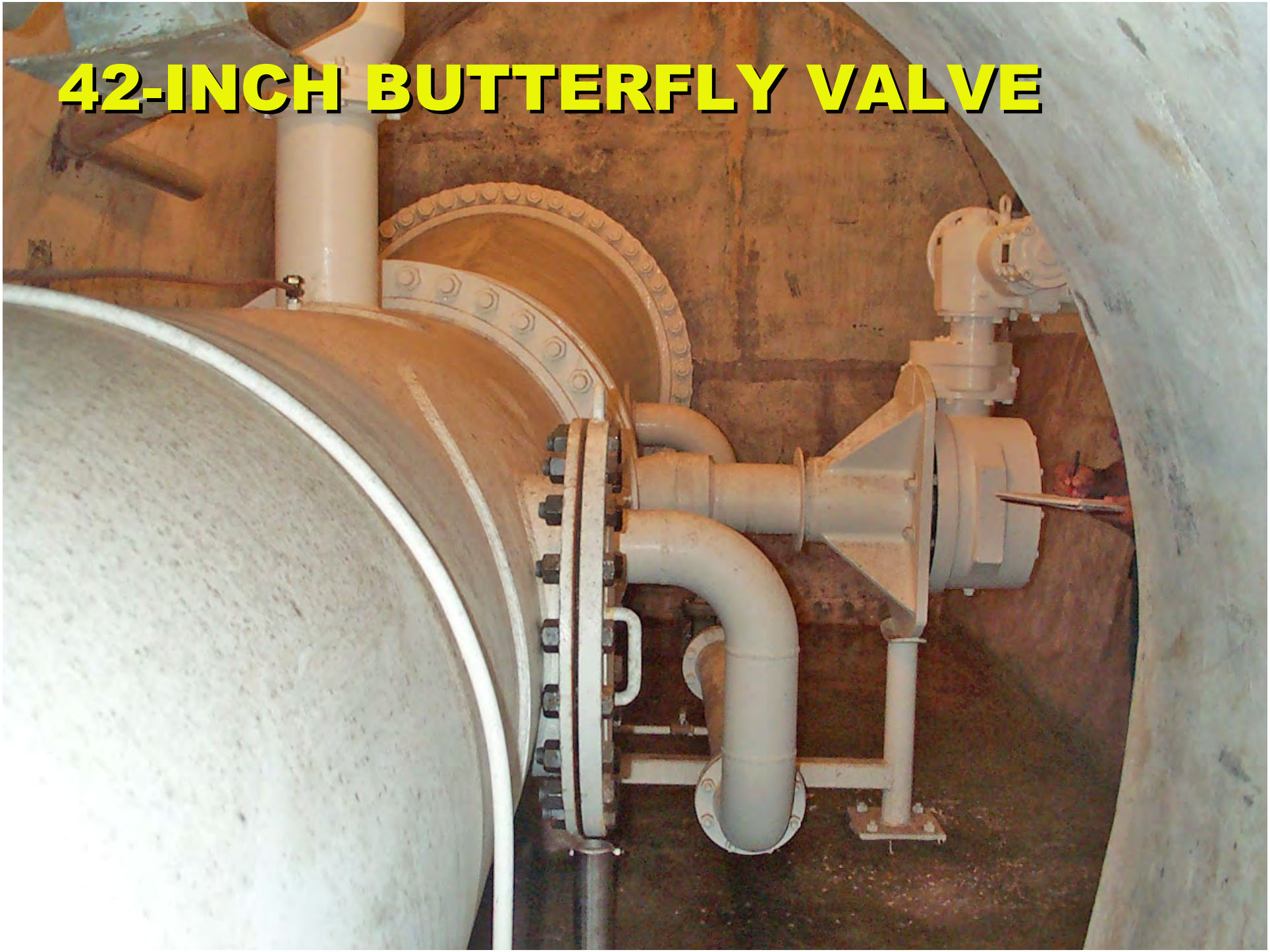
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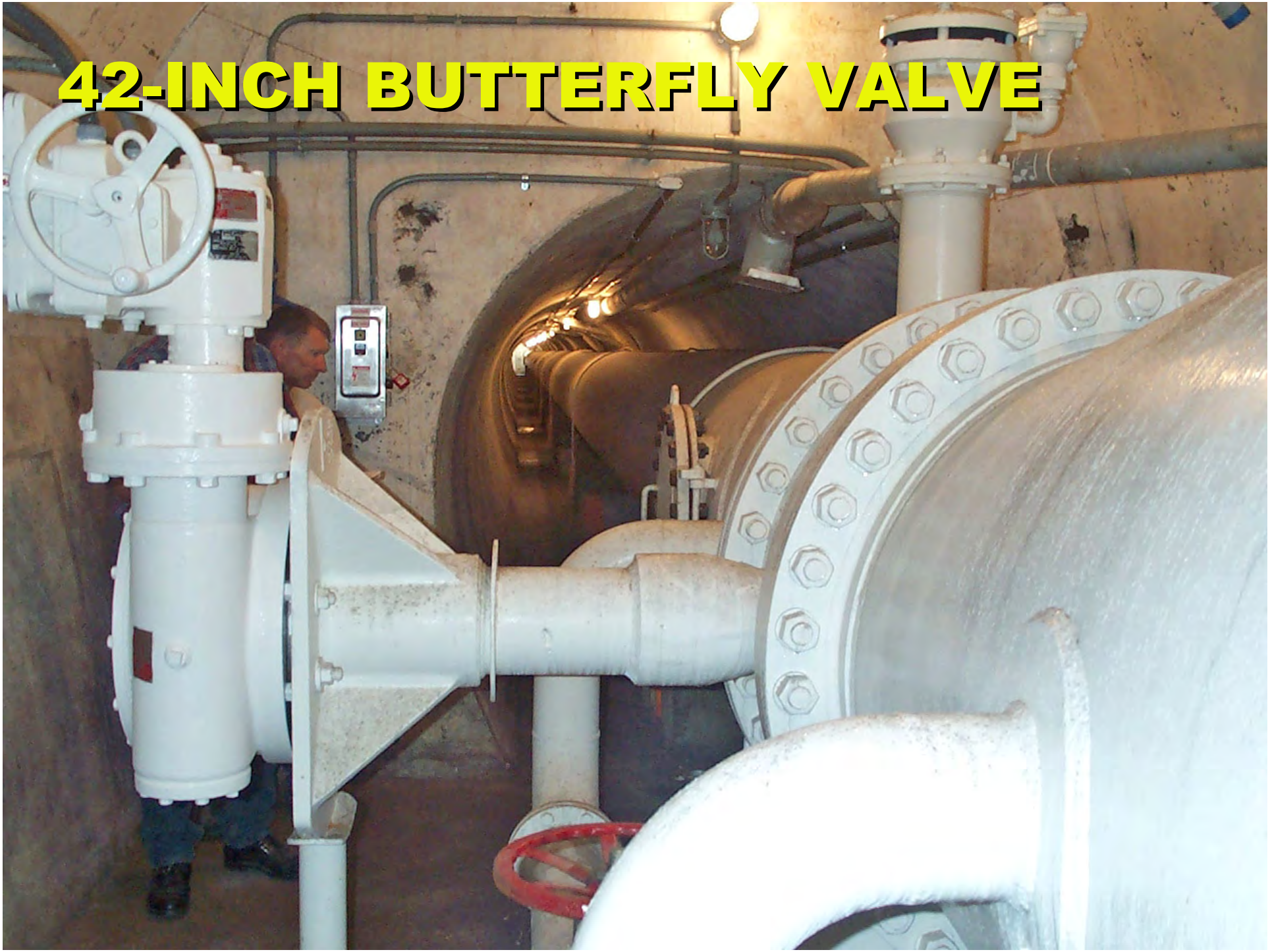
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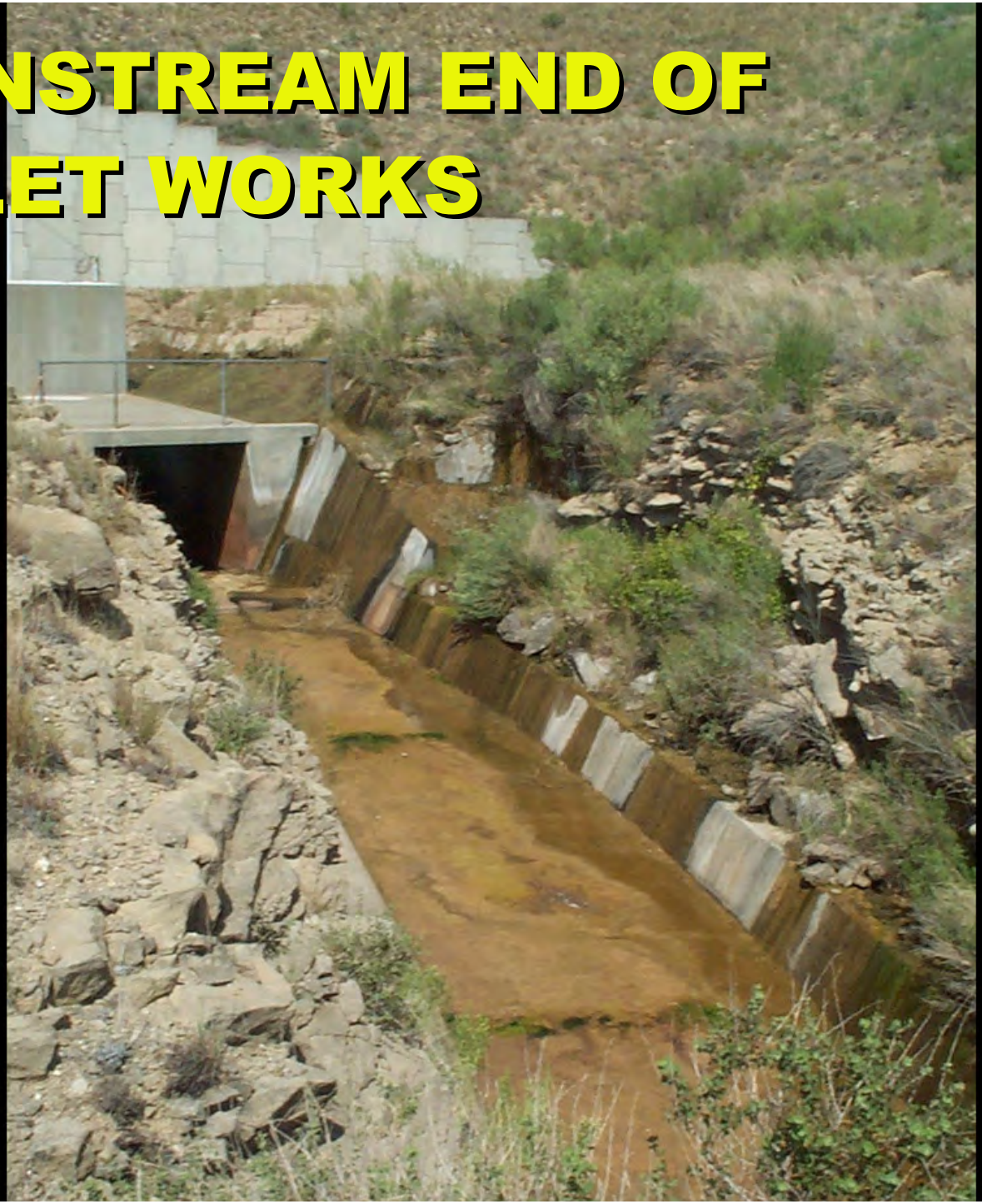



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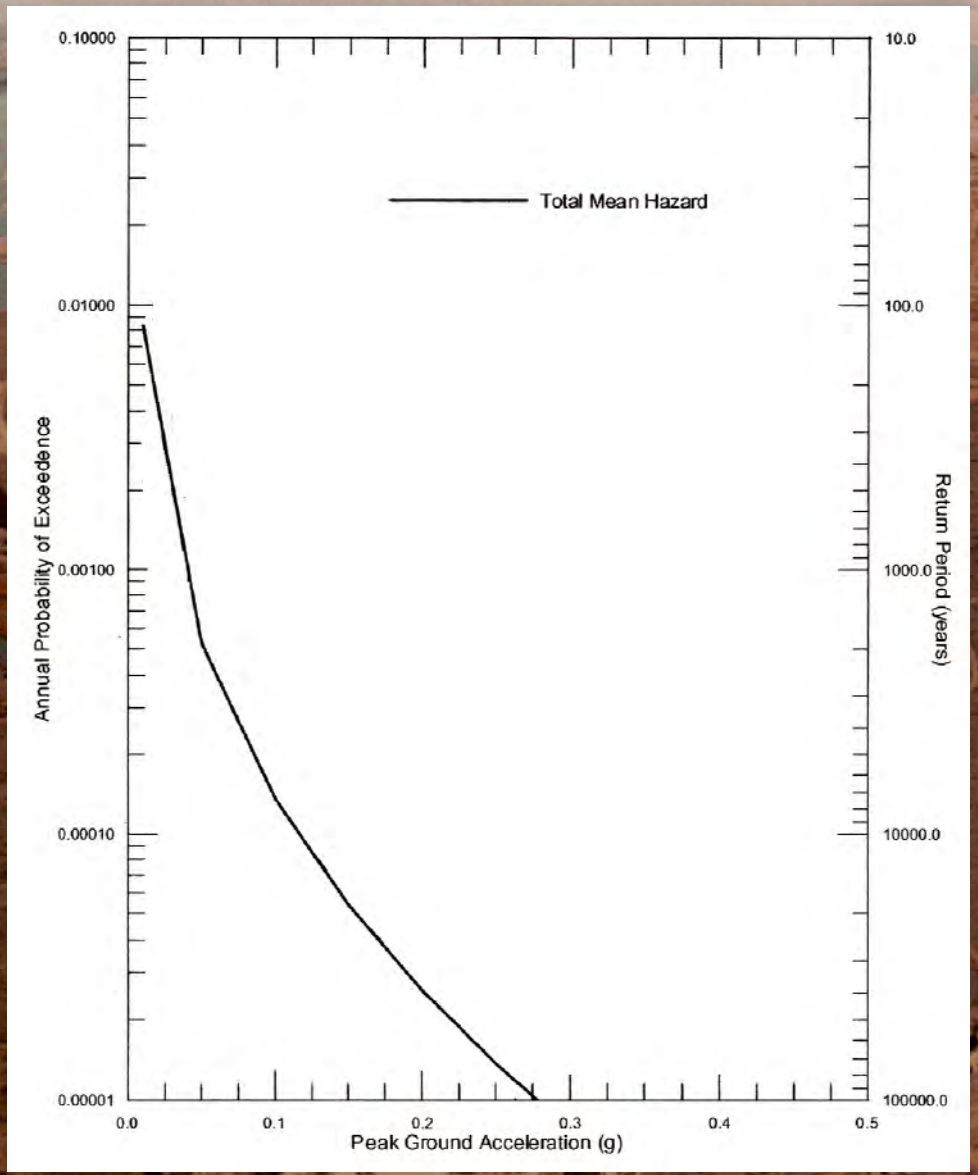
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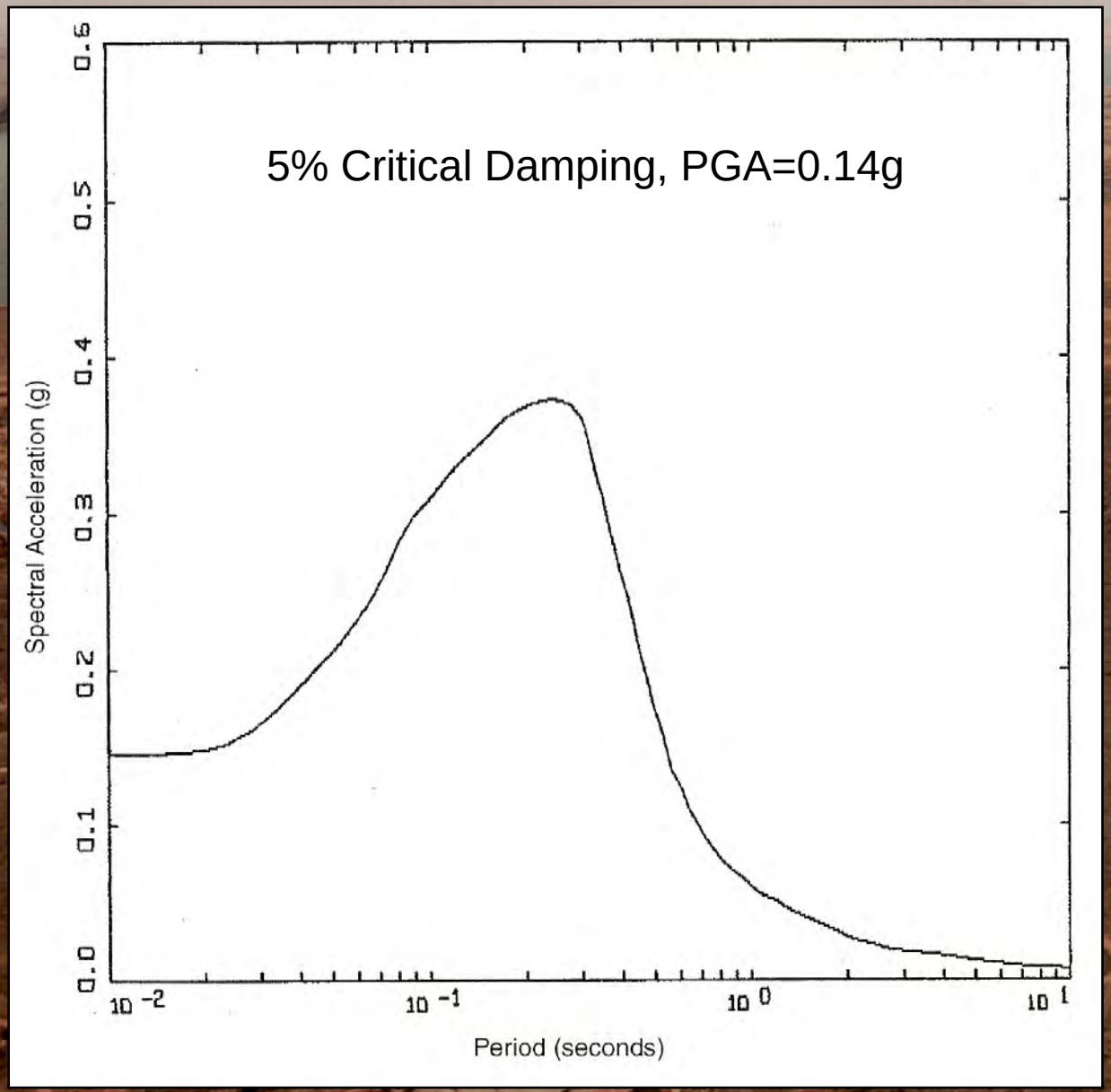
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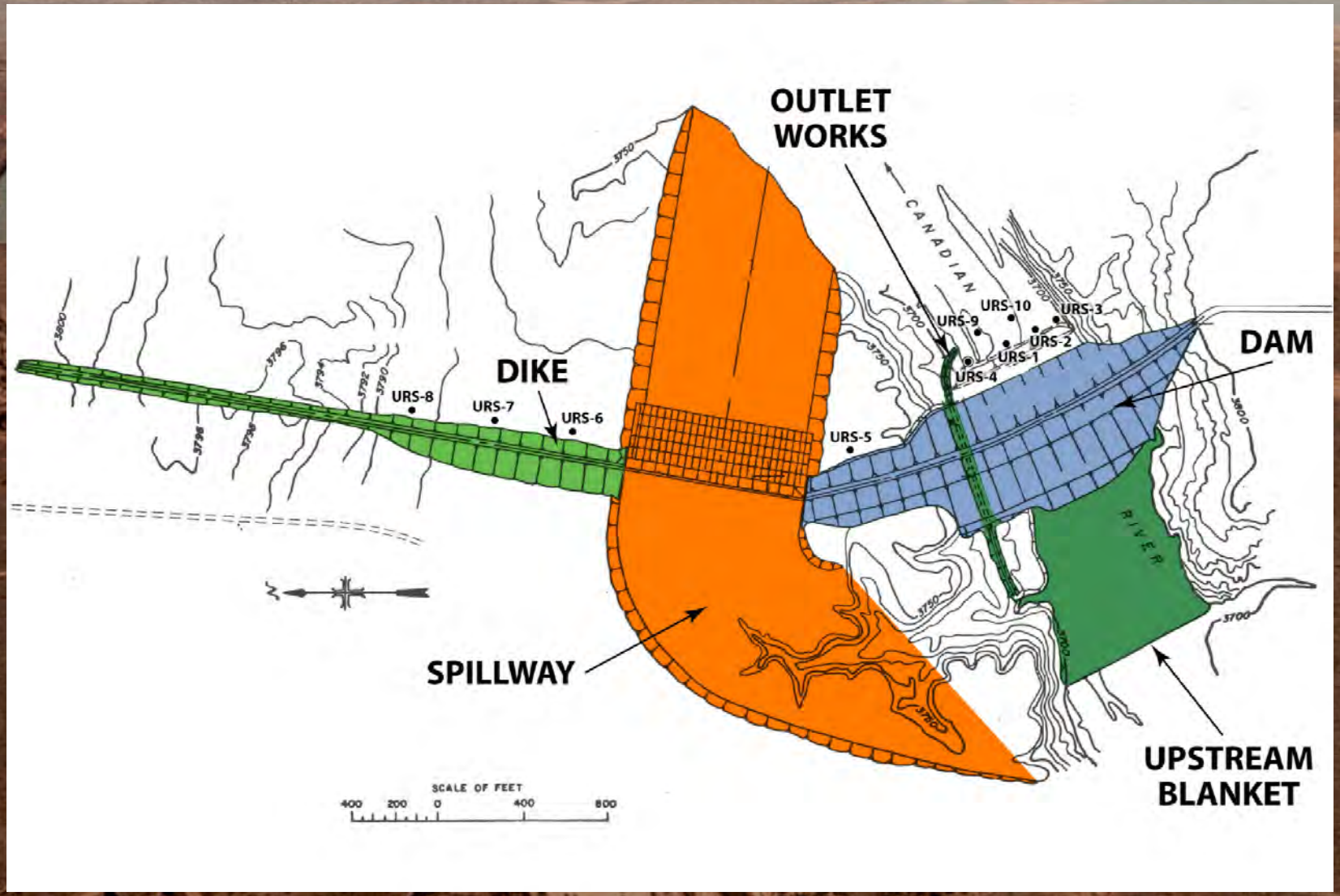
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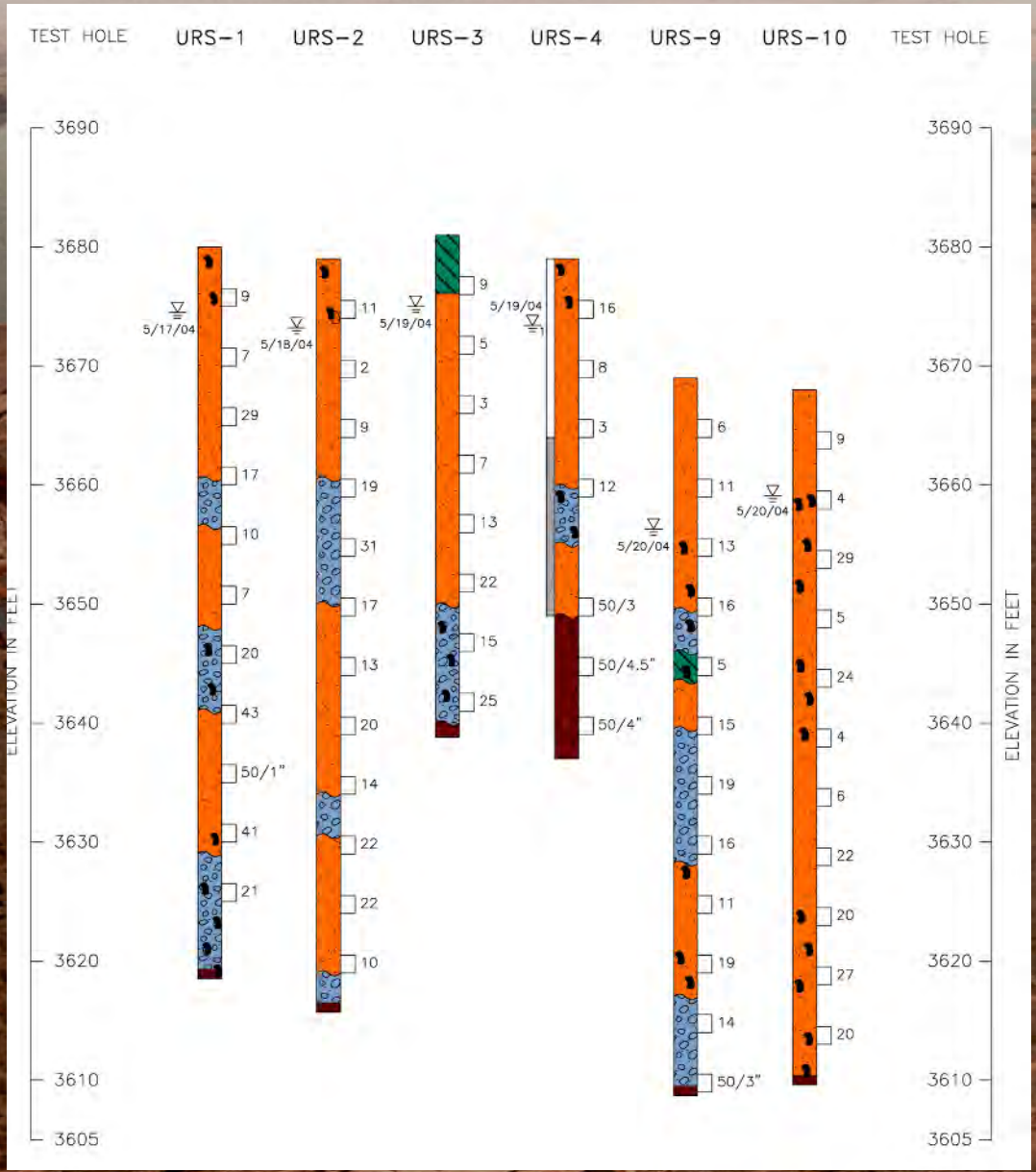
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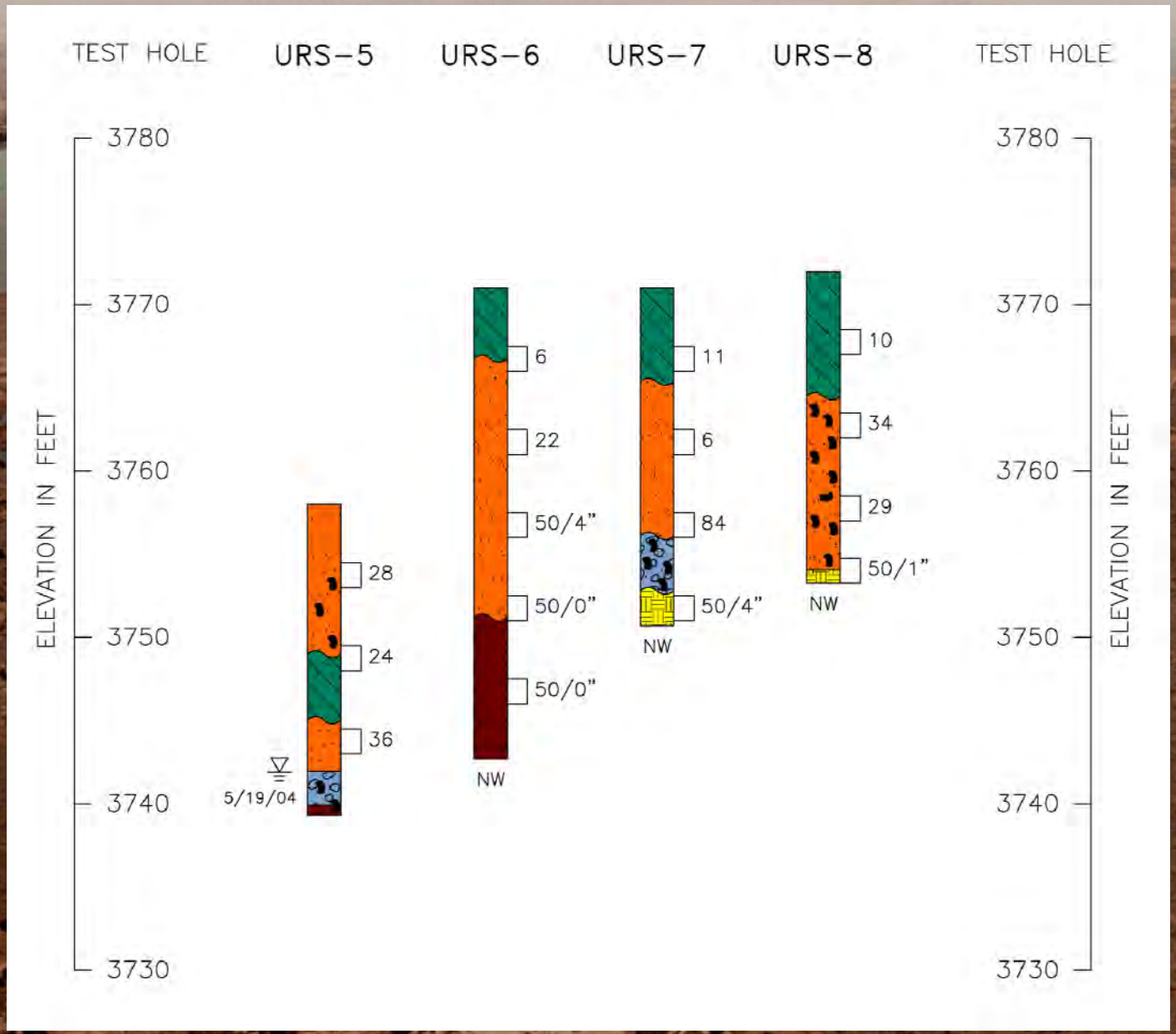
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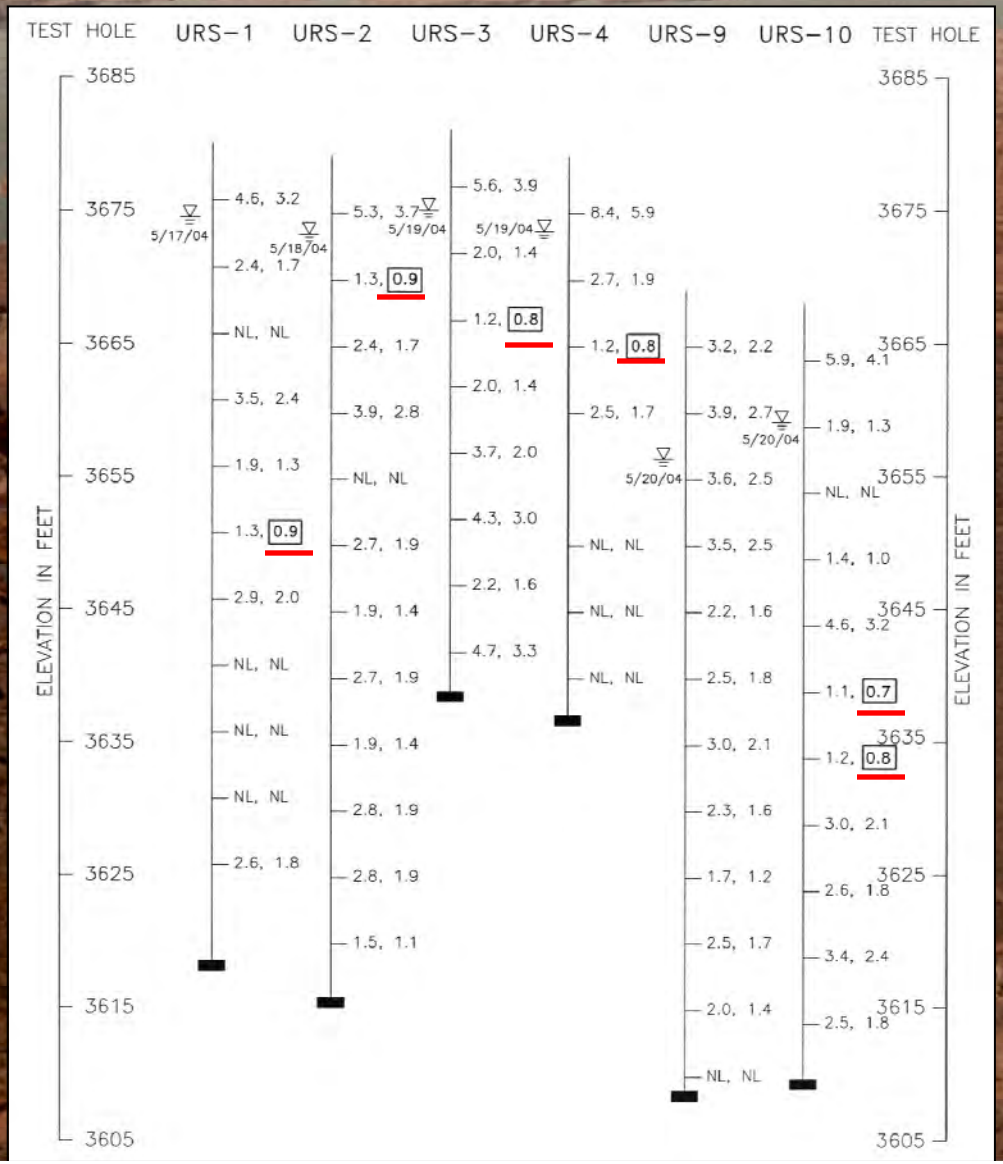
TEST BORINGS - DIKE



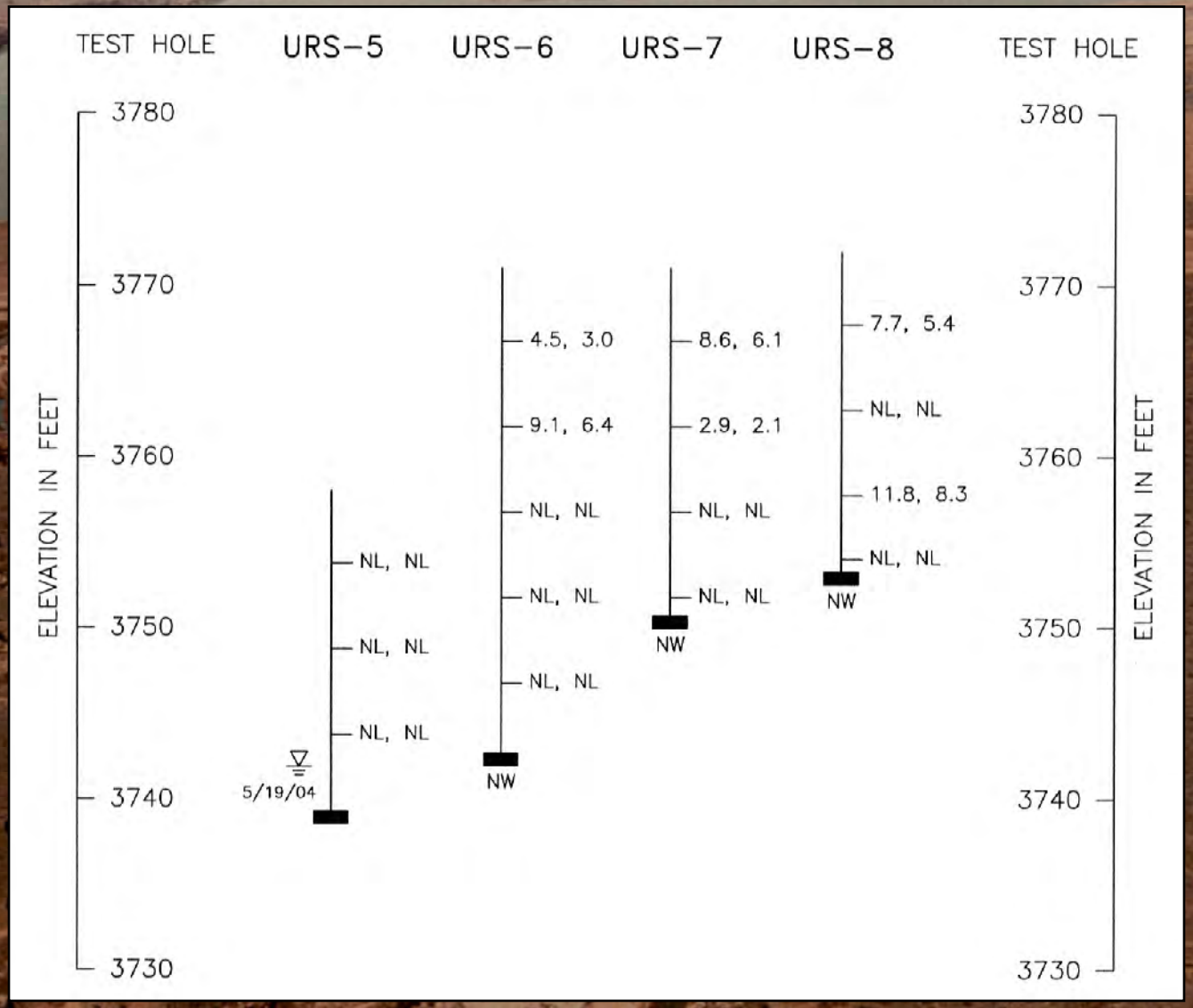
LIQUEFACTION ANALYSIS METHOD

- Procedures based on SPT blowcounts and empirical charts, Youd et al, 2001
- Comparison of cyclic resistance ratio (CRR) with cyclic stress ratio (CSR)
- Analysis included adjustments for:
  - earthquake magnitude
  - fines content
  - overburden pressure
  - depth
  - SPT hammer
- Consideration of gravel effects

LIQUEFACTION ANALYSIS RESULTS – DAM FOUNDATION



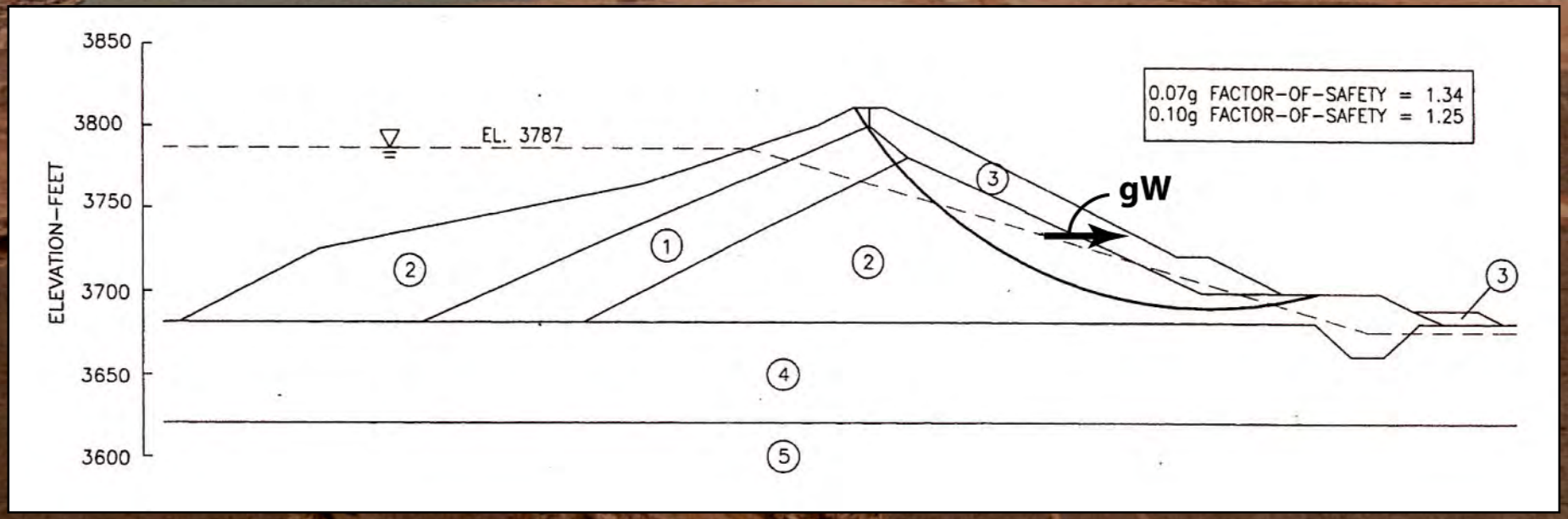
LIQUEFACTION ANALYSIS RESULTS – DIKE FOUNDATION



PSUEDO-STATIC STABILITY ANALYSES

- Psuedo-static coefficients:
  - 5,000 year: 0.07g
  - 10,000 year: 0.10g
- 50% of alluvium PGAs
- NMOSE requires “50% of bedrock acceleration, but not less than 0.05g”
- Analysis coefficients are conservative

EXAMPLE P-S STABILITY ANALYSES



PSUEDO-STATIC ANALYSIS RESULTS

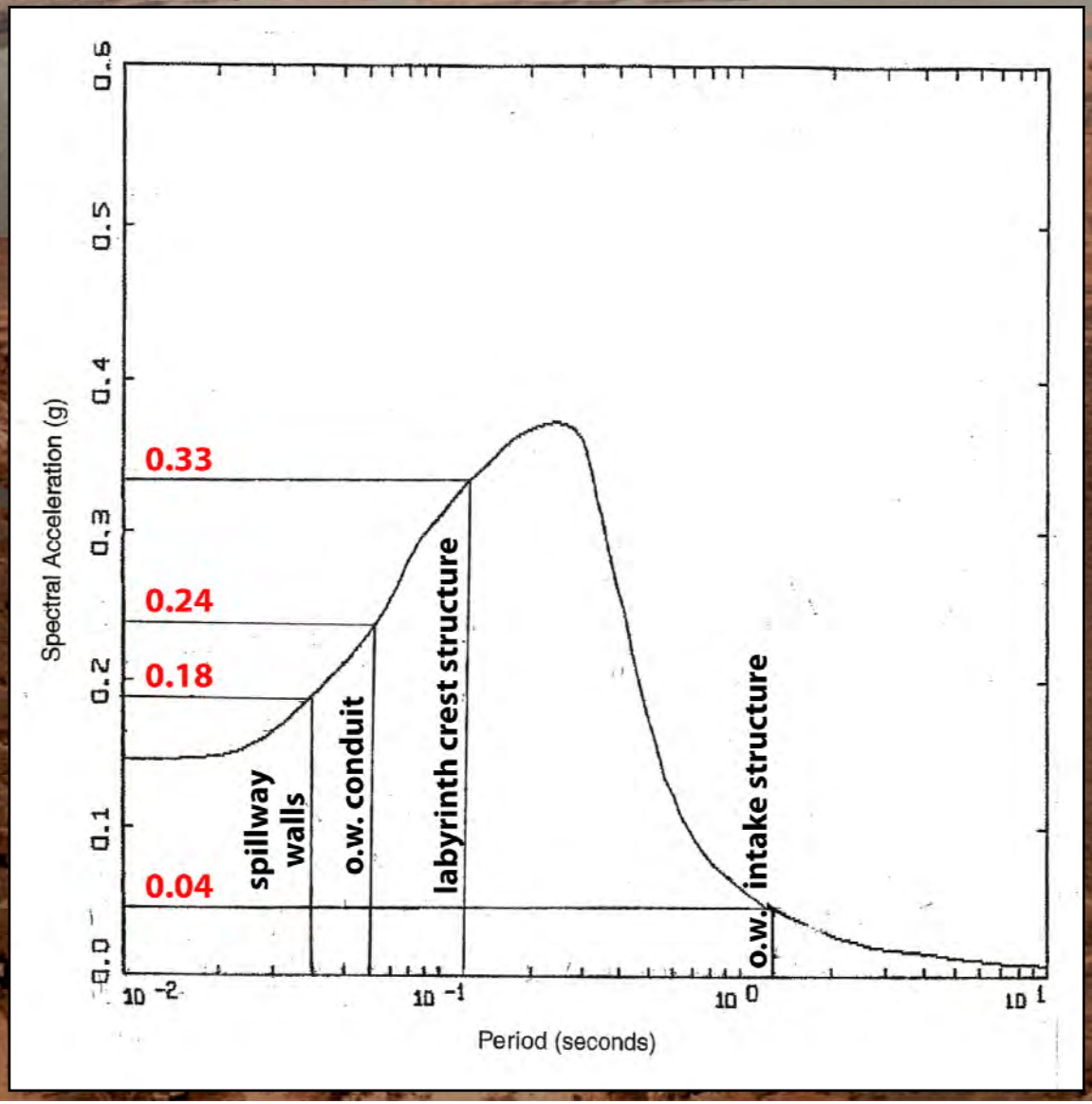
Case	Calculated Factors of Safety	
	5,000 year 0.07g	10,000 year 0.10g
Downstream	1.34 to 1.48	1.25 to 1.36
Upstream	1.77 to 1.85	1.54 to 1.62

NMOSE requires FS $\geq$ 1.1

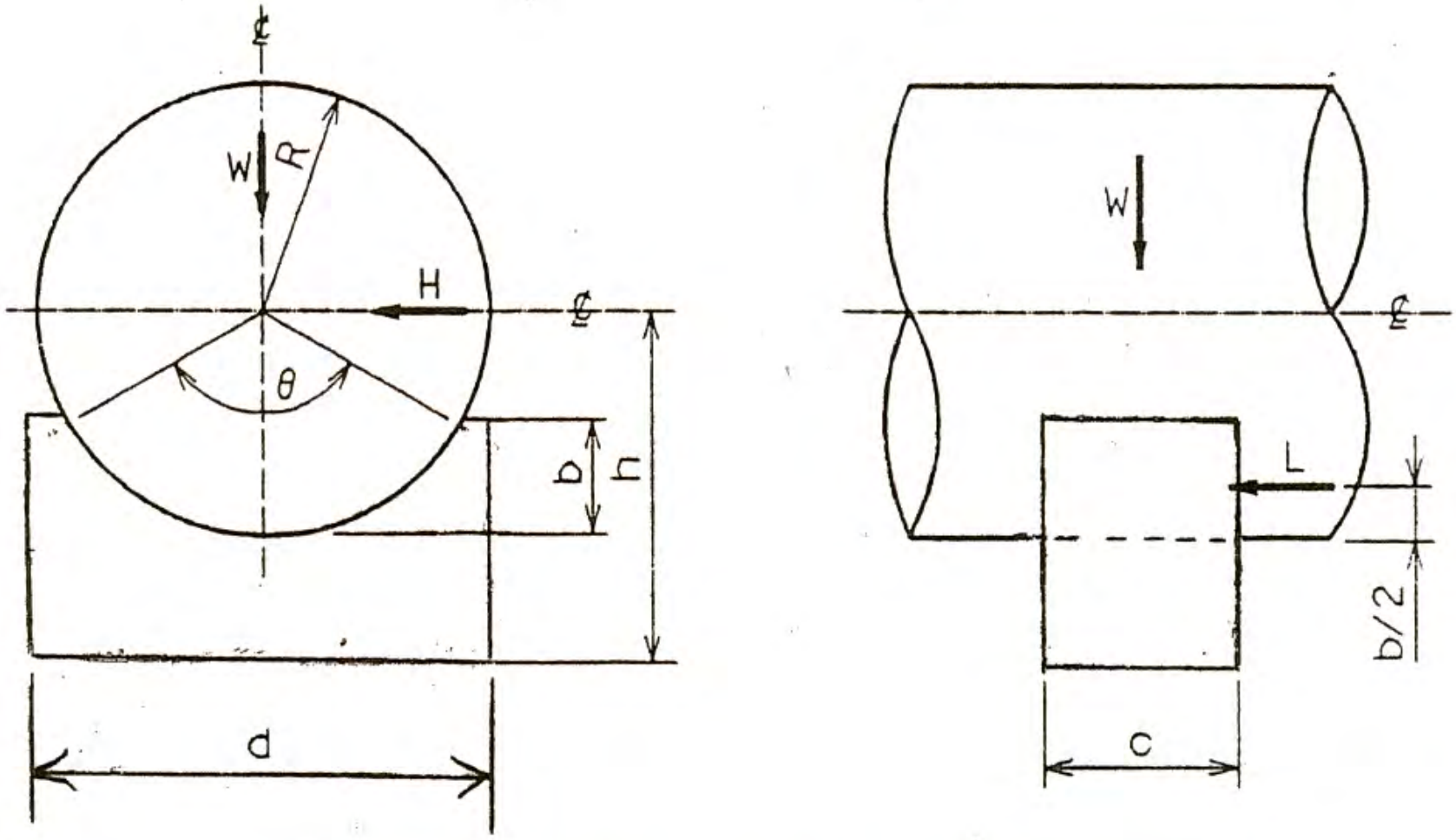
OUTLET WORKS SEISMIC STABILITY ANALYSIS

- Psuedo-dynamic analysis
- EQ load based on response spectrum
- Components analyzed:
  - Intake structure
  - 42-inch steel pipe and saddles
  - Valves
- Components not analyzed:
  - Upstream conduit
  - Horseshoe tunnel

PSHA – RESPONSE SPECTRUM – 5% CRITICAL DAMPING



ILUSTRATION OF METHOD



SADDLE SUPPORT SATBILITY DIAGRAM

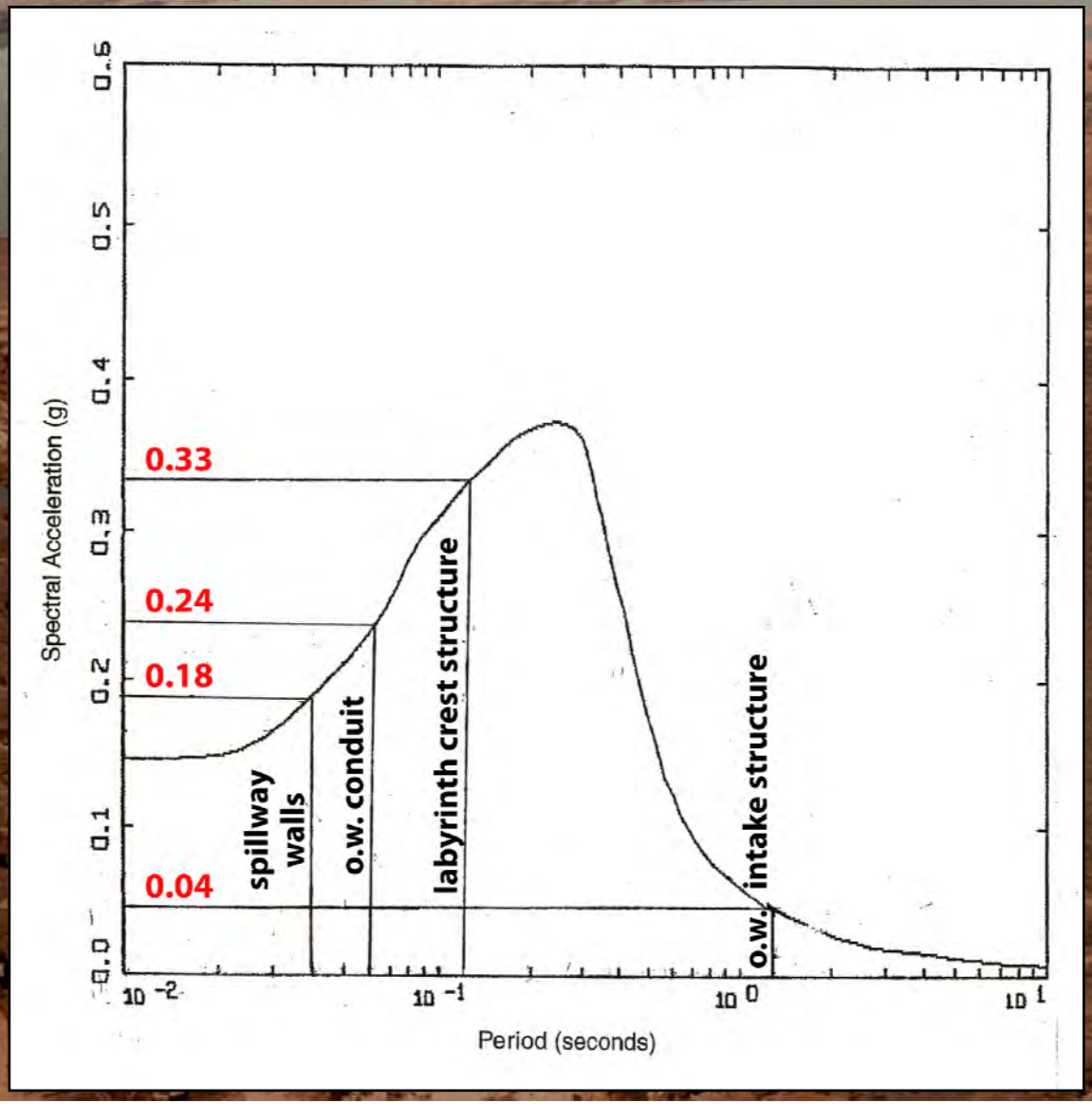
OUTLET WORKS SEISMIC STABILITY ANALYSIS RESULTS

- For all components analyzed:
  - Stability is acceptable
  - Calculated stresses are acceptable

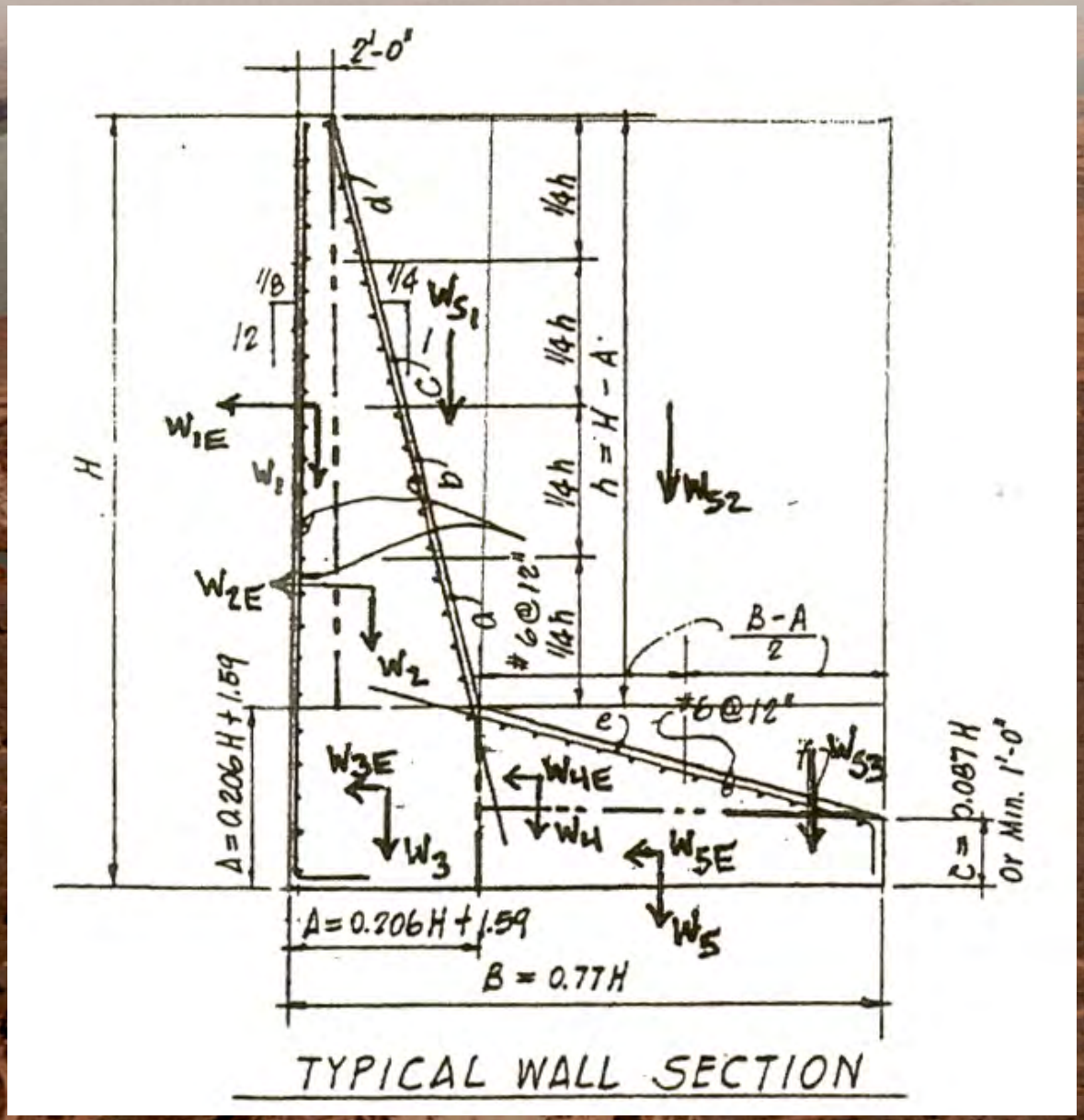
OUTLET WORKS SEISMIC STABILITY ANALYSIS

- Same method of analysis used for outlet works
- Components analyzed:
  - Labyrinth crest structure
  - Spillway gravity side walls
- Components not analyzed:
  - Ogee crest structure
  - Downstream chute

PSHA – RESPONSE SPECTRUM – 5% CRITICAL DAMPING



ILUSTRATION OF METHOD



TYPICAL WALL SECTION

SPILLWAY SEISMIC STABILITY ANALYSIS RESULTS

- For all components analyzed:
  - Stability is acceptable
  - Calculated stresses are acceptable

SUMMARY AND CONCLUSIONS

- Site seismicity is relatively low
- Liquefaction potential judged to be low
- Embankment psuedo-static stability is adequate
- Appurtenant structure expected seismic performance judged to be acceptable
- No remedial action required


QUESTIONS?


Contact Information:
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Dispersive Clays – Experience and History of the NRCS (Formerly SCS)

Presented at Tri-Service Infrastructure Conference

August 2-5, 2005, St. Louis, MO

By: Danny McCook, Geotechnical Engineer, National Design, Construction, and Soil Mechanics Center, Fort Worth, TX

Natural Resources Conservation Service

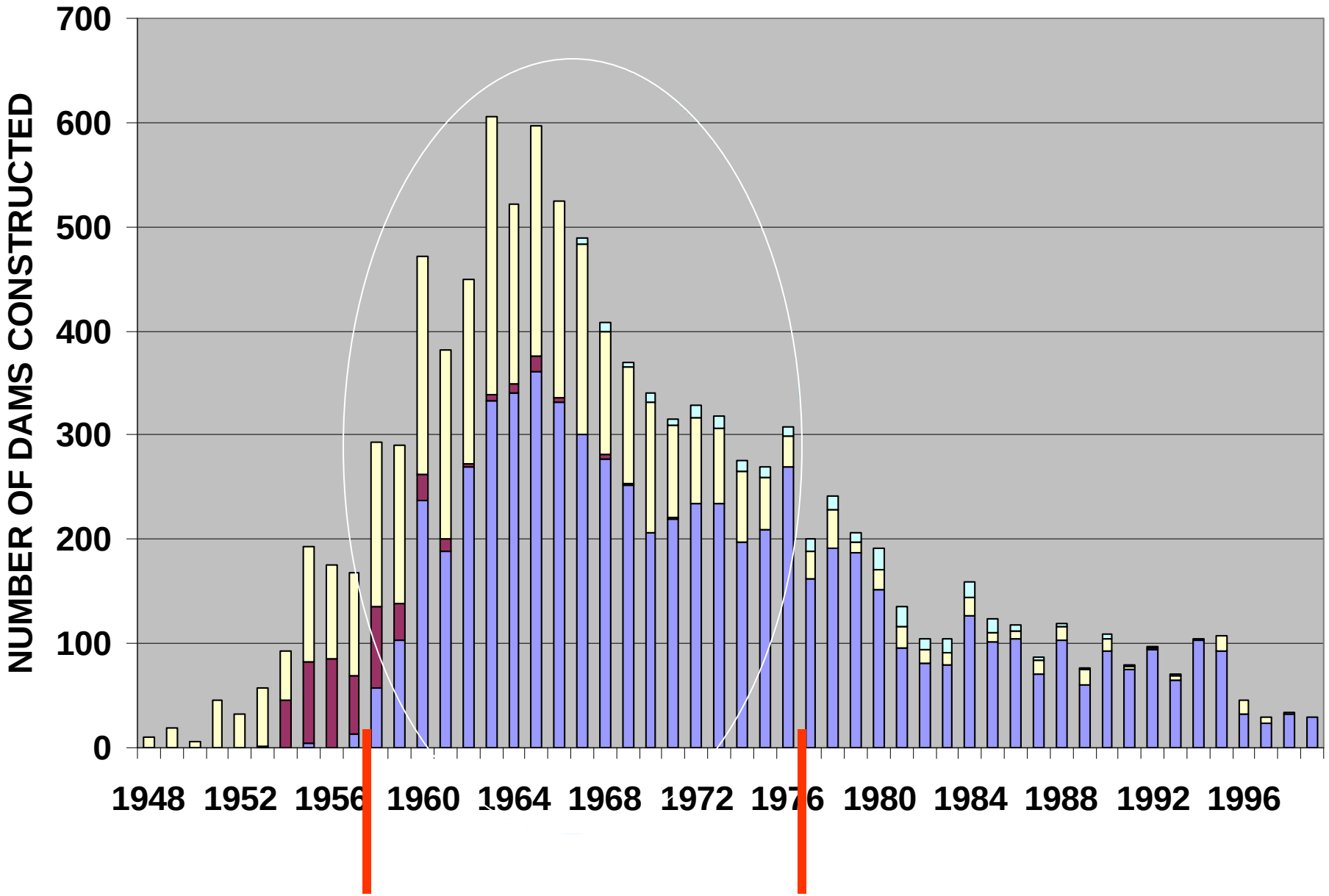


Outline

- NRCS Embankment Construction History
- Problems with Dispersive Clays
- Tests Developed
- Defensive Design/Remedial Treatment

Embankment Construction History of NRCS

- 11,000 + dams constructed between 1949 and present
- Average dam height 25-60 feet
- Majority are single-purpose flood control
- Significant number of high hazard, multi-purpose dams included


NUMBER OF DAMS CONSTRUCTED
700
600
500
400
300
200
100
0
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996

Typical Dam



Engineering Problems with Dispersive Clays

- Erosion of external slopes - embankments and channel slopes
  - Jugging
  - Rilling

Surface Erosion and Jugging



Surface Erosion and Jugging



Engineering Problems with Dispersive Clays

- Internal erosion of fills through cracks
  - Catastrophic failures
  - Usually occur during first filling
  - Hydraulic fracturing contribution

Owl Creek 13, OK

- No eyewitness
- Failure tunnel along right side of conduit
- Failure tunnel about 18 feet in diameter with bottom near bottom of conduit

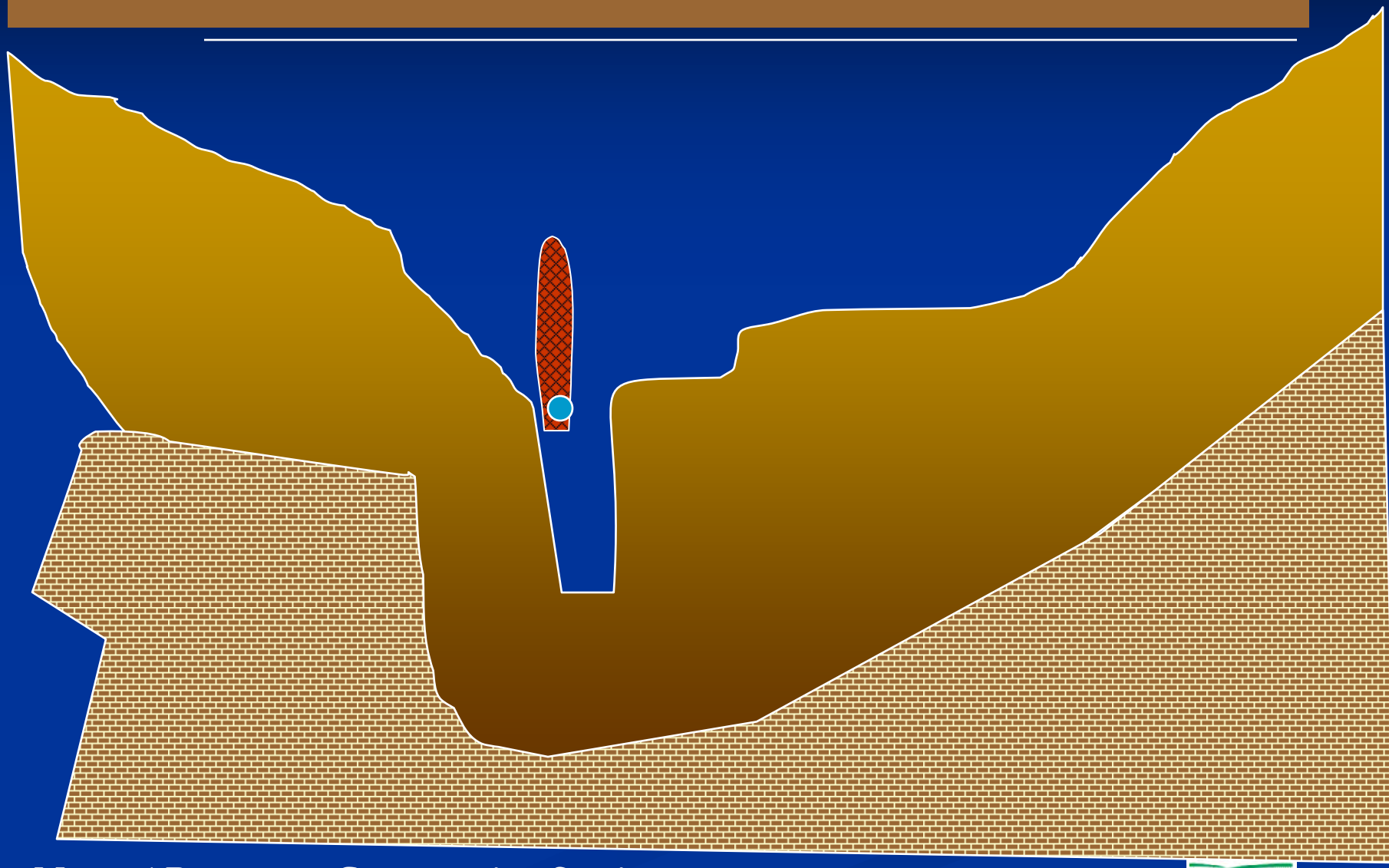
Example Failures – Owl Creek, Site 13



Example Failures – Owl Creek, Site 13



Example Failures – Owl Creek, Site 13



Owl Creek 13 Causes of Failure

- Embankment compacted dry of optimum
- Highly dispersive clays
- Conduit installed on highly compacted trench backfill
- Near sharp bedrock profile under dam

Upper Red Rock Site 20, Oklahoma

- Failure on Second First Filling
- Site Built in 1973
- Impounded pool of water until 1986 with no problems
- Unprecedented pool level reached that was 4 feet below dam crest
- Failure tunnel 40 feet to side of conduit




Note water flowing from other smaller flow concentration



Upper Red Rock, Site 20, OK – Causes of Failure

- Lack of bonding of lifts in embankment – discing not required
- Embankment highly compacted – imprints of sheepsfoot obvious in exposed lifts
- Highly dispersive clays

Upper Red Rock, Site 20, OK – Causes of Failure

- Embankment highly compacted – imprints of sheepsfoot obvious in exposed lifts



Common Factors in Failures

- Ten of 11 OK dams failed on first filling, usually shortly after construction during a large rainfall event that filled reservoir rapidly
- Failures begin with an initial leak that gradually eroded a tunnel. If the tunnel became large enough, the roof collapsed forming a breach

Conditions Common in Problems/Failures

- Excavations made to install conduits (transverse to the embankment) with too steep side slopes
- Variable foundation materials and thicknesses of materials along alignment of embankment

Conditions Common in Problems/Failures

- Difficulty in compacting under haunches of circular conduits.
- Interruptions in fill placement and lack of bonding of lifts
- Dispersive clays –almost universal factor

Conditions Common in Problems/Failures

- Embankments constructed at overly high density and low water contents (brittle fill)
- Absence of chimney filter or filter diaphragm in design – no failures since inception of filter diaphragms in mid 1980's
- Differential settlement associated with conduit

Other observations

- Hundreds of dams built of similar soils and the same quality of construction did not fail
- Speed of filling and conditions conducive to hydraulic fracturing are thought to have been less severe at the non-failed dams.
- Differential settlement is thought to be a prime contributor to hydraulic fracturing

USACE Wister Dam

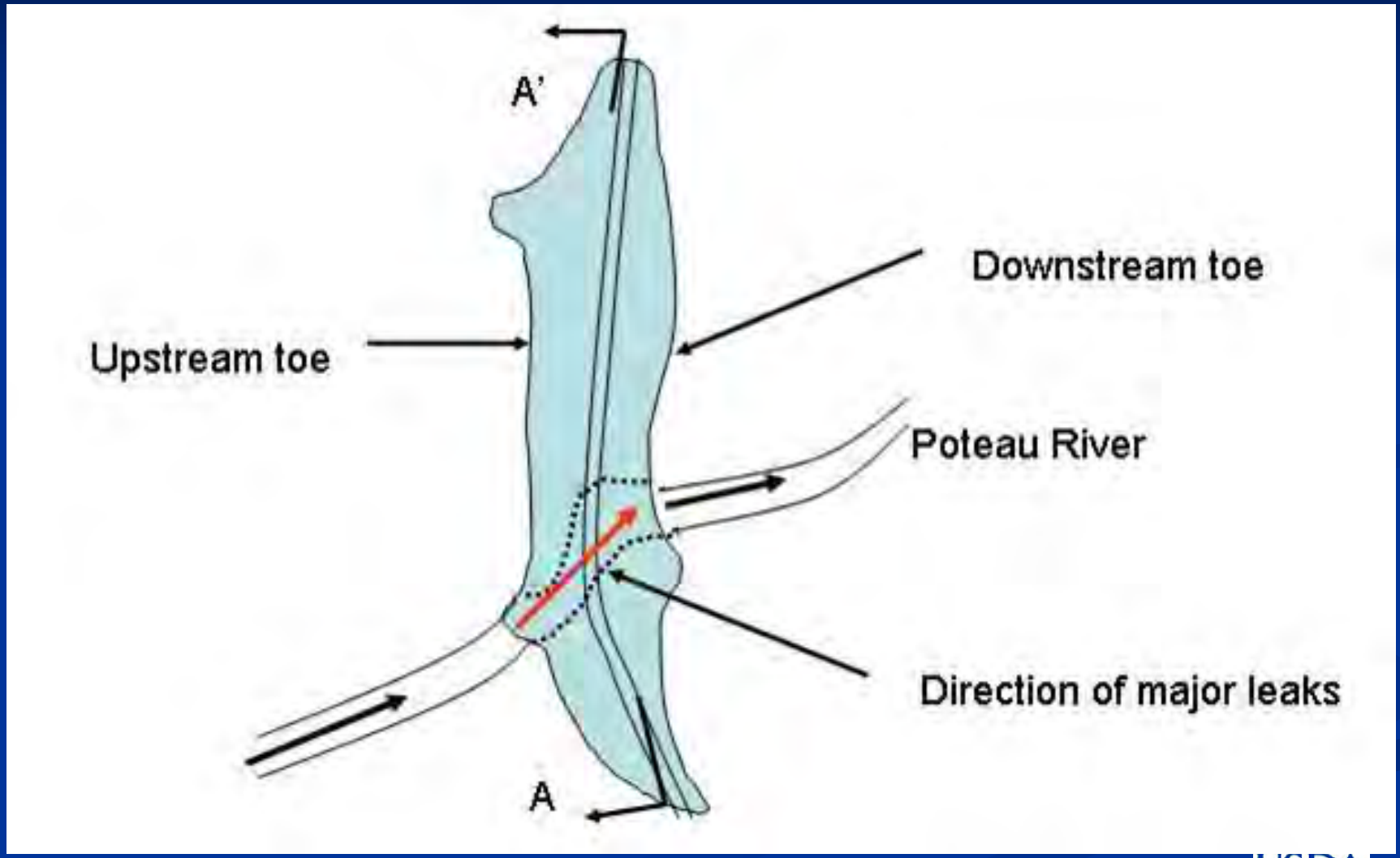
- Constructed in 1949
- Concentrated muddy leaks and sinkholes occurred on first filling
- Failure narrowly averted by drawing down reservoir
- Reported by Casagrande in 1950 Boston Society of Civil Engineers article

Wister Dam

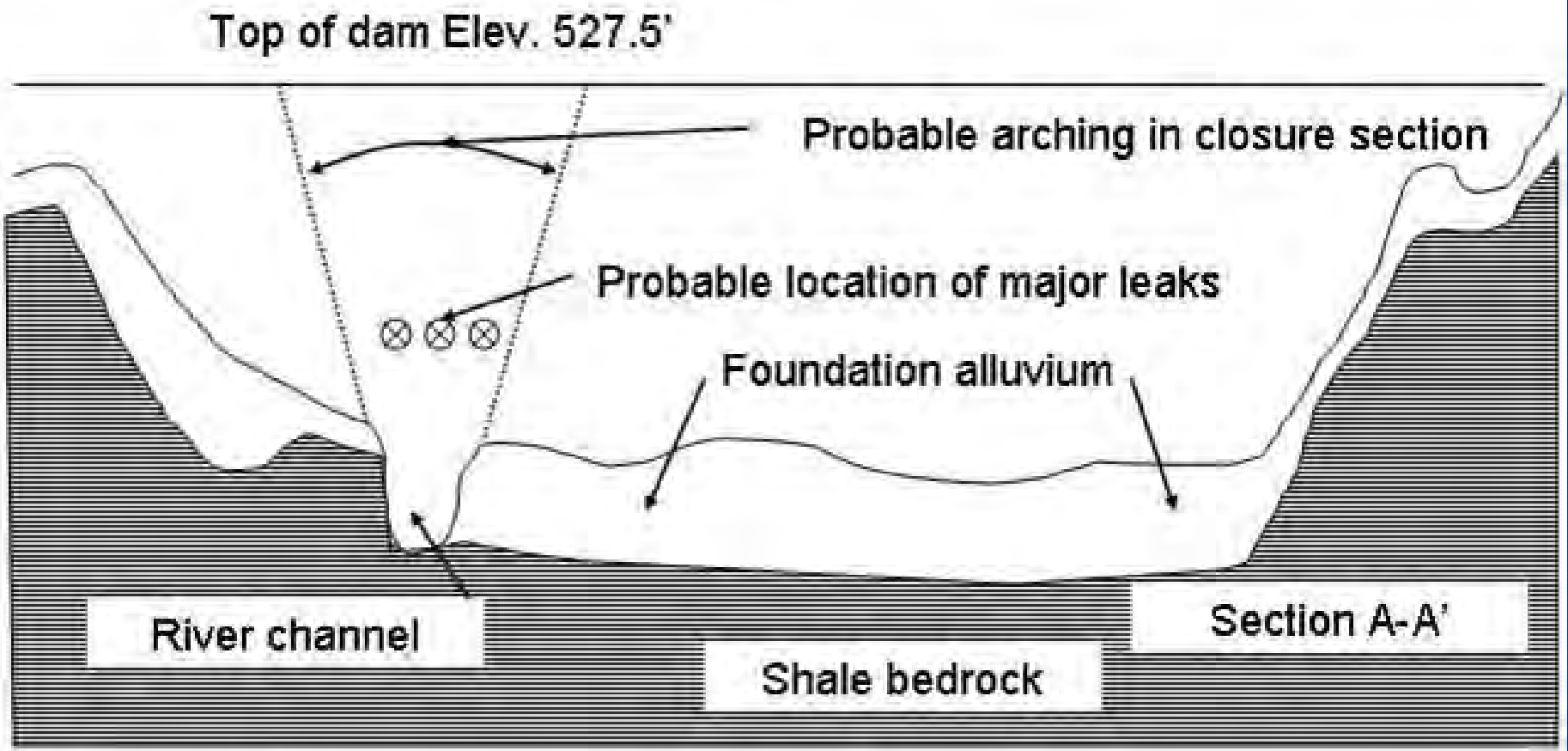
- Extensive remediation in early 1990's



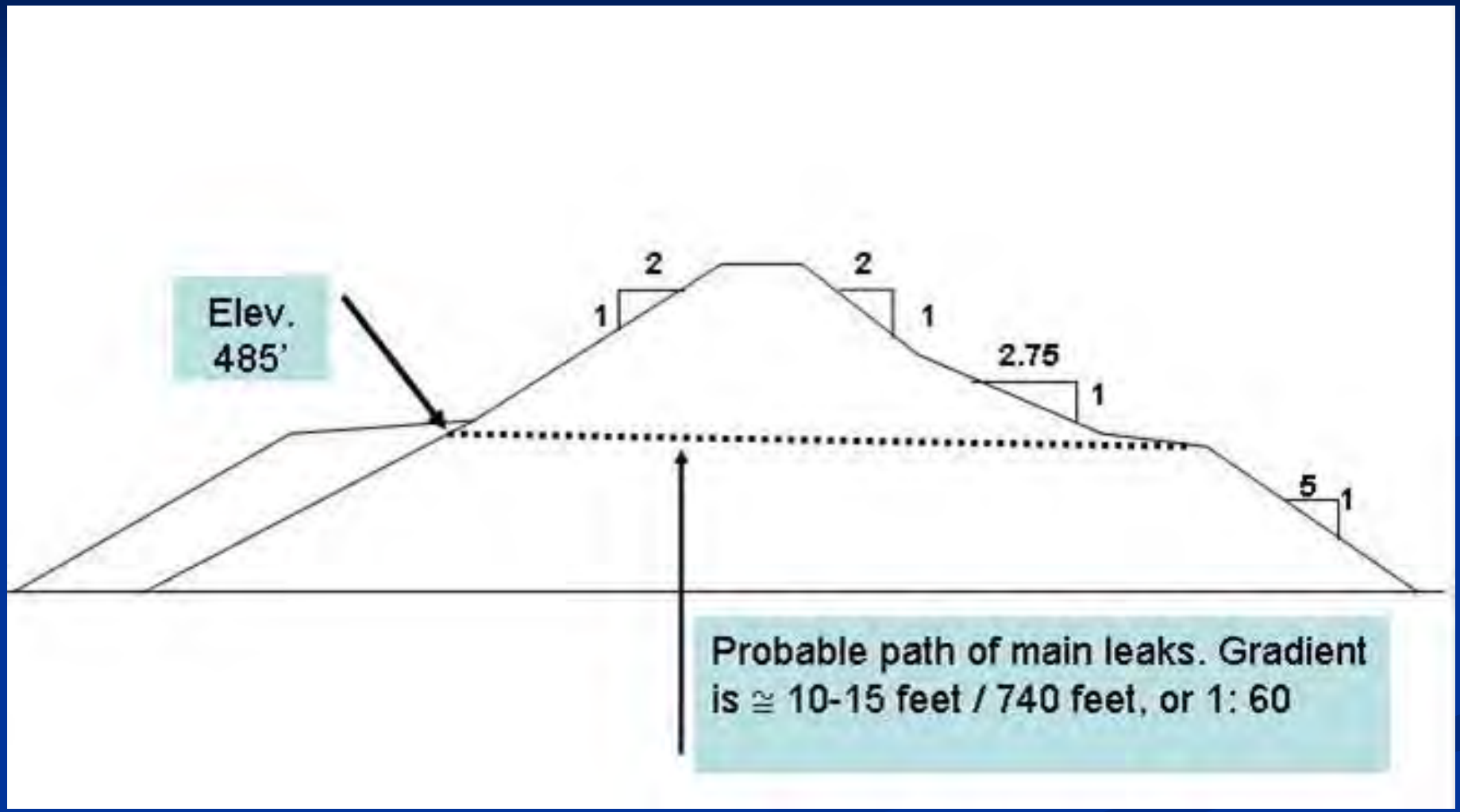
Closure Section at Wister Dam, Oklahoma



Closure Section at Wister Dam, Oklahoma



Closure Section at Wister Dam, Oklahoma



SCS and Dr. James Sherard

Dr. Sherard cooperated with then SCS in extensive research into the basic nature of dispersive clays and in filter research.

His studies expanded to include sites such as the USACE Wister dam in Eastern Oklahoma and many others.



References

- June, 1972, – ASCE Specialty Conference, Performance of Earth and Earth-Supported Structures, Purdue, IN "Piping in Earth Dams of Dispersive Clay", Sherard, Decker and Ryker

References

- June, 1972, – ASCE Specialty Conference, Performance of Earth and Earth-Supported Structures, Purdue, IN "Hydraulic Fracturing in Low Dams of Dispersive Clay", Sherard, Decker and Ryker

References

- April, 1976 – ASCE Geotechnical Journal, "Identification and Nature of Dispersive Soils" – Sherard, Dunnigan and Decker

References

- September, 1979 – ASCE Geotechnical Journal, "Dispersive Soil Problem at Los Esteros Dam" – Decker (retired SCS) and McDaniel

References

- ASTM Special Technical Publication 623 "Dispersive Clays, Related Piping and Erosion in Geotechnical Projects"
- May, 1977

References

- Waterways Experiment Station Technical Report GL-79-14 "Dispersive Clay at Granada Dam ...." – Ed Perry (retired WES)

Dispersive Clays

- Definition
  - Fine-grained CL, CH, MH, ML
  - Dispersive fines in Sands/Gravels
  - Sodium predominates pore-water chemistry

Dispersive Clays

- Origin of Dispersive Clays
  - Marine Shale Formations
  - Loess
  - Soils derived from metamorphic rocks, igneous rocks, and limestones are rarely dispersive

Dispersive Clays

- Sampling for Dispersion
  - Random, Discrete Samples Advisable
  - Moist Samples !
  - Numerous samples required for statistical inferences
  - Don't composite!!

Tests for Dispersive Clays

- Normal tests do not identify dispersive clays – they have the same Atterberg limit and other characteristics as normal clays.
- Dispersive character results from chemical imbalance

Dispersive Clays

- Recognition
  - Outcrops - Extreme rilling/jugging
  - Sometimes mottled but color not helpful

Outcrops of Dispersive Clay



Outcrops of Dispersive Clay



Outcrops of Dispersive Clay



Dispersive Clays

- Field Tests
  - Crumb Test
  - Portable Pinhole
  - Field Turbidity Ratio

Dispersive Clays

- Laboratory Tests
  - Crumb
  - Double Hydrometer
  - Pinhole
  - Chemical Test on Pore Water Extract

Dispersive Clays

- Crumb Test – ASTM Method 6572
  - 1 - No reaction
  - 2 - Cloud immediately around clod
  - 3 - Cloud is appreciable distance from clod but does not cover bottom or meet on opposite side
  - 4 - Cloud spreads around bottom and may cover bottom

Dispersive Clays

- Crumb Test
  - 3 and 4 reactions very positive indicator of dispersive soil
  - Unfortunately, 1 and 2 reactions not always positive for lack of dispersive nature

Crumb Test 1

Water in glass remains clear - Ignore any slaking of clod - examine only for turbidity



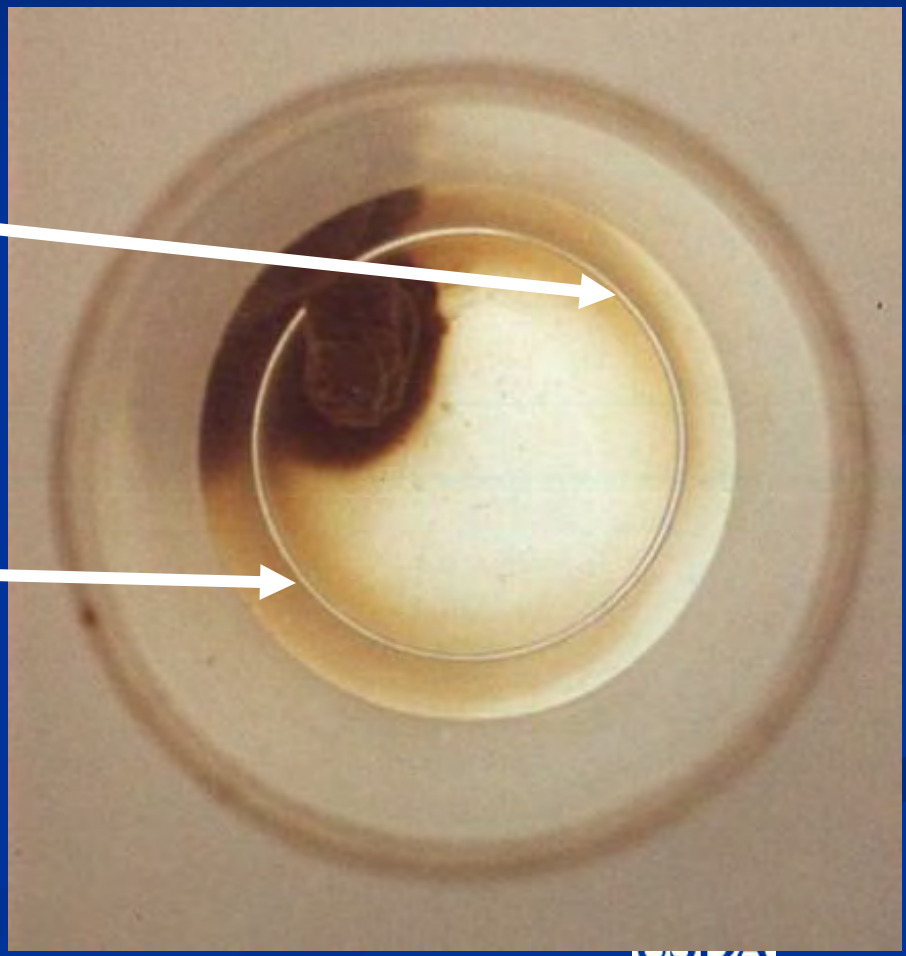
Crumb Test 2

A hint of a cloud occurs very near the clod - it does not spread significantly away from the clod however



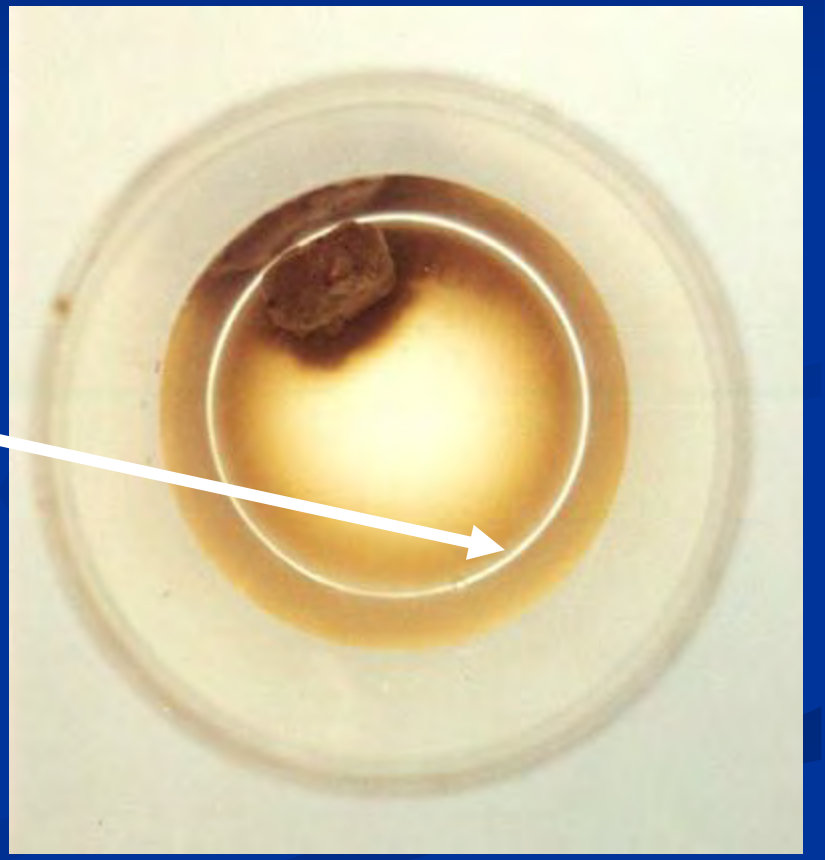
Crumb Test 3

A colloidal cloud spreads a considerable distance from the clod - it does not spread completely to meet at the opposite side of the glass



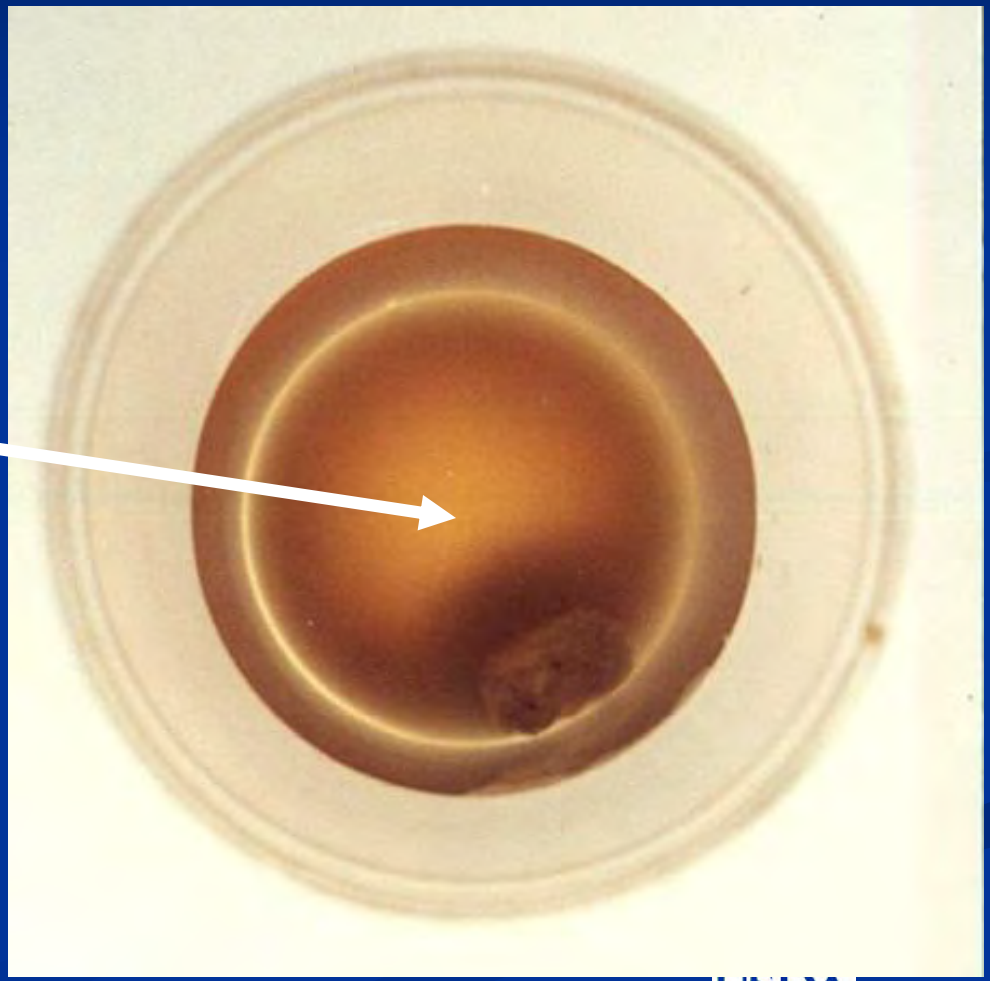
Crumb Test 4

A colloidal cloud spreads so that the cloud meets at the opposite side of the glass



Crumb Test 4 alternative

A colloidal cloud may be so extensive that the whole bottom of the glass is covered- obviously also a 4 reaction



Double Hydrometer Test

- ASTM Standard D4221
  - Compares 0.005 mm size of natural soil to that of chemically dispersed sample



Double Hydrometer

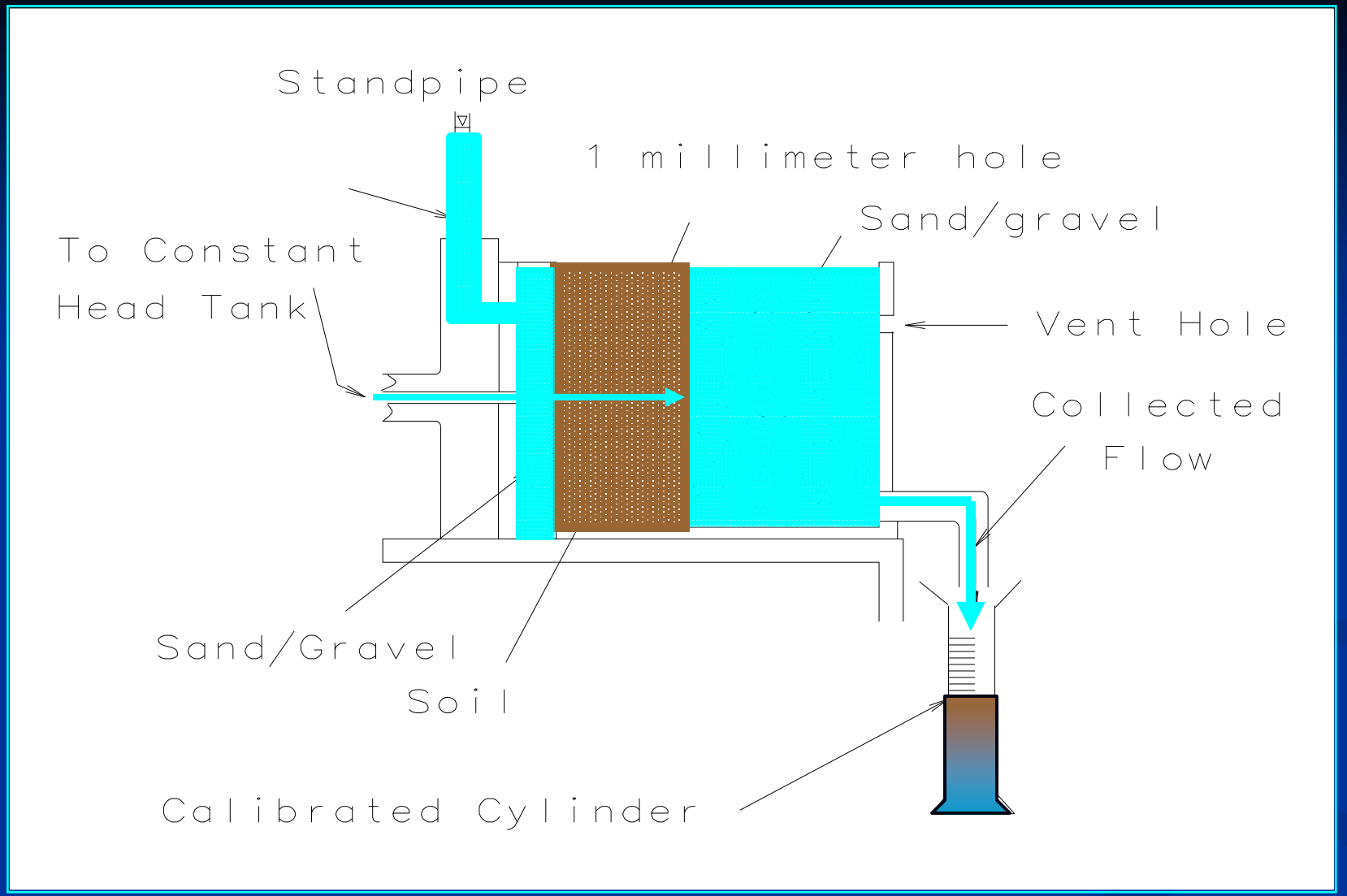
- % Dispersion is ratio of 5 micron size natural to 5 micron size chemically dispersive, expressed as percentage

$$\%\,Dispersion = \frac{\%\,5\mu\_naturally\_prepared}{\%\,5\mu\_chemically\_dispersed}\,x100$$

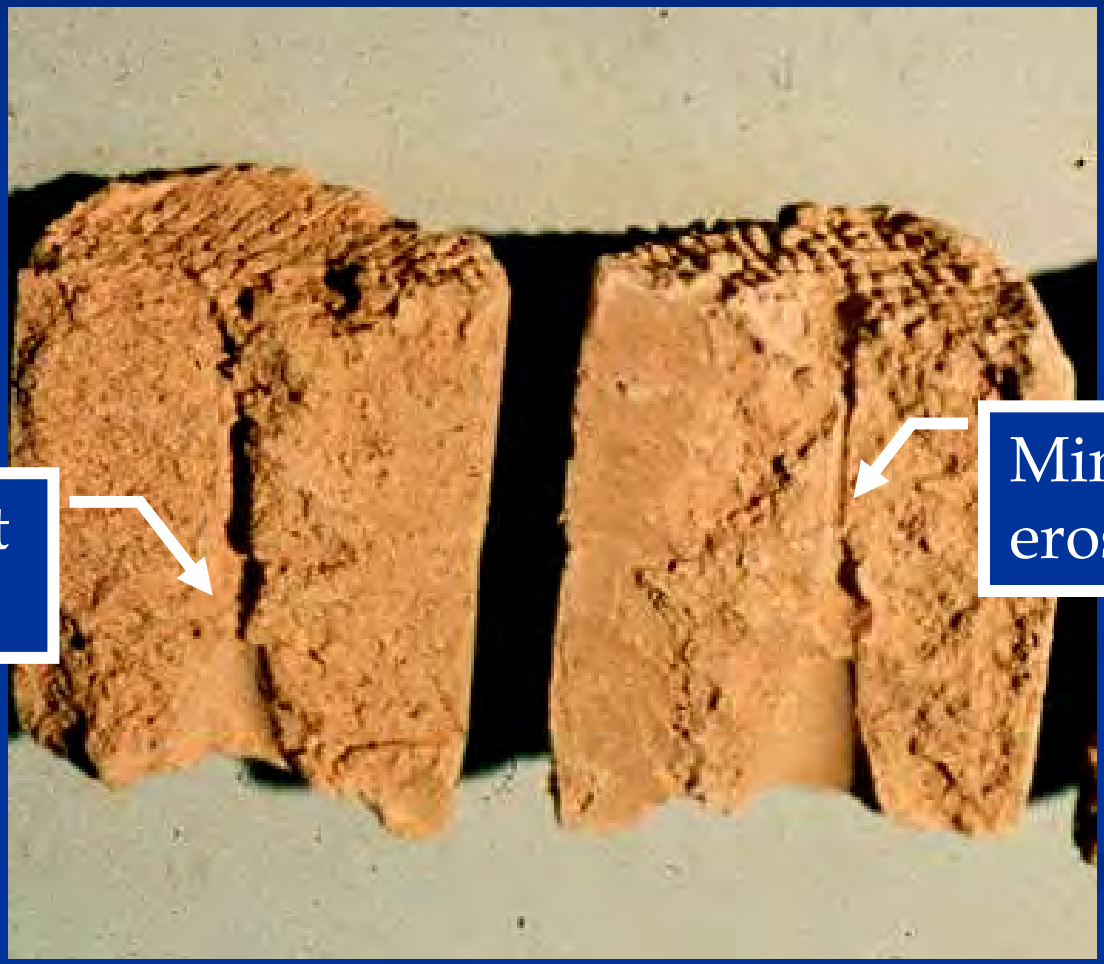
- **< 30 % Not Dispersive**
- **30-60 % Transition**
- **> 60 % Dispersive**

Pinhole Test - ASTM D4647

- Direct measure of erosivity
- Dispersive soils fail rapidly under flow at 2 inches of head
- Non-dispersive soils show little erosion under flow at 40 inches of head
- Ratings are D-1, D-2, ND-4, ND-3, ND-2, and ND-1 most dispersive to non-dispersive)


Standpipe
1 millimeter hole
Sand/gravel
To Constant
Head Tank
Vent Hole
Collected
Flow
Sand/Gravel
Soil
Calibrated Cylinder

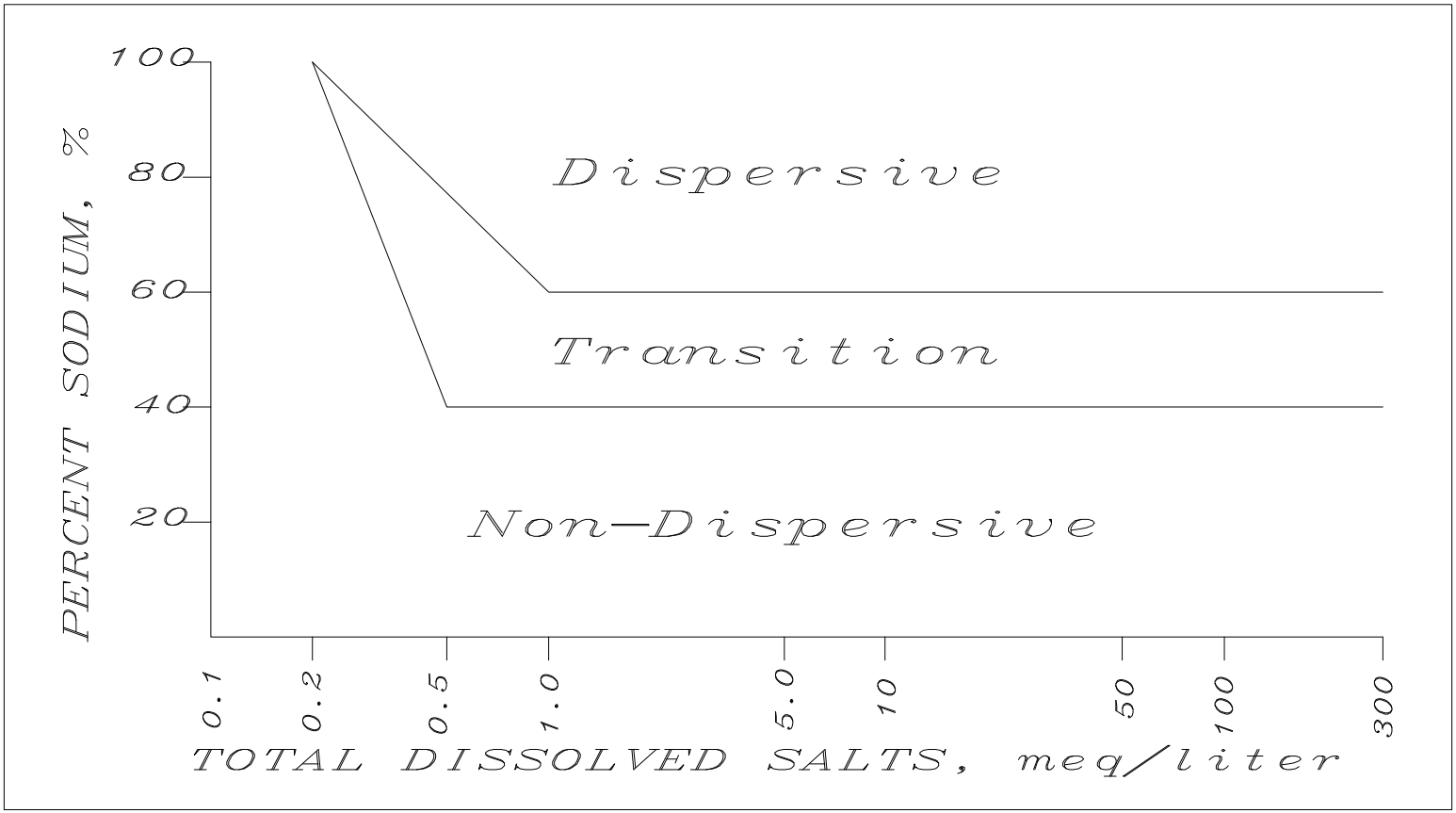
Pinhole Samples



Dispersive Clays

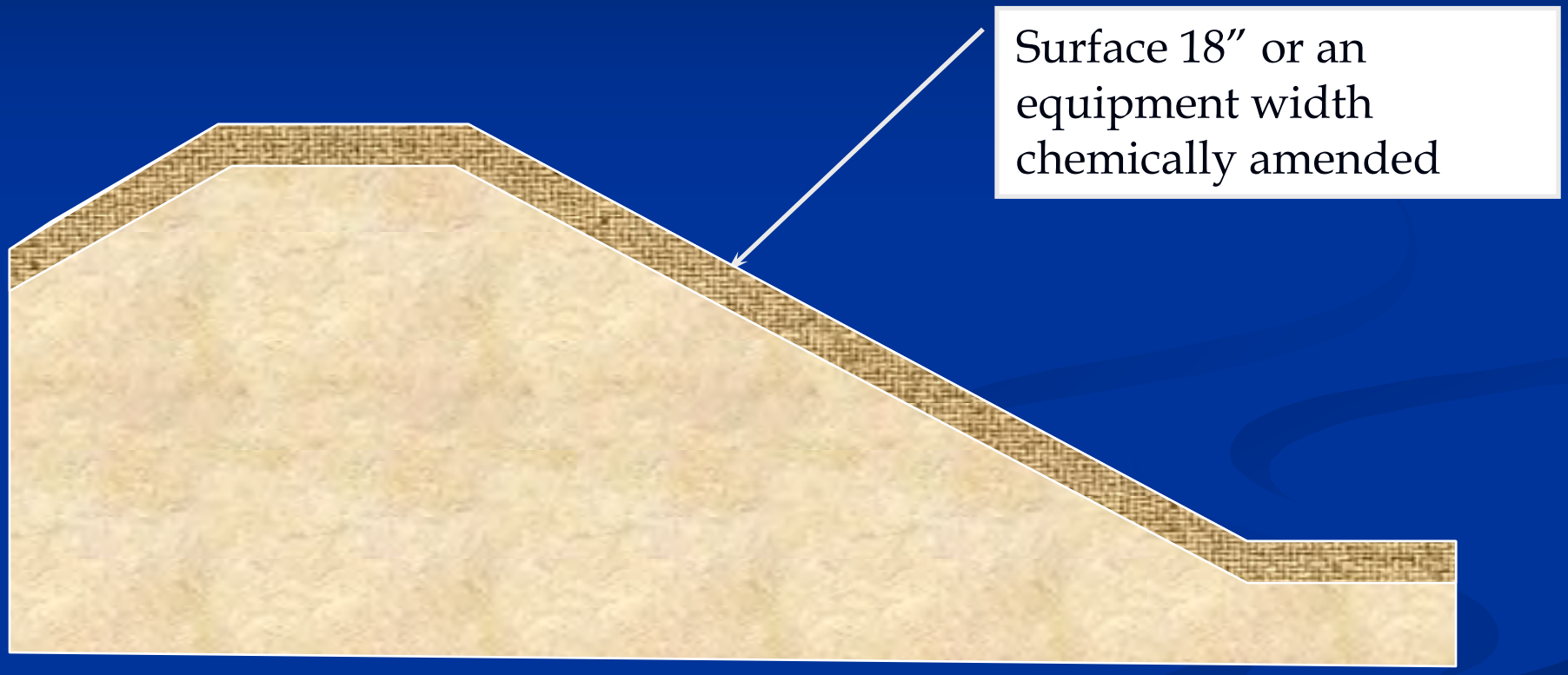
- Chemical Test on Pore Water Extract
  - Dispersive soils have > 60 % of total salts being sodium
  - Non-dispersive soils have < 40 % of total salts being sodium

Chemical Test For Dispersion



- Design Measures to Combat Dispersive Clays
  - Selective Placement/Avoidance
  - Chemical Amendments
    - hydrated lime
    - fly ash
    - alum
    - gypsum

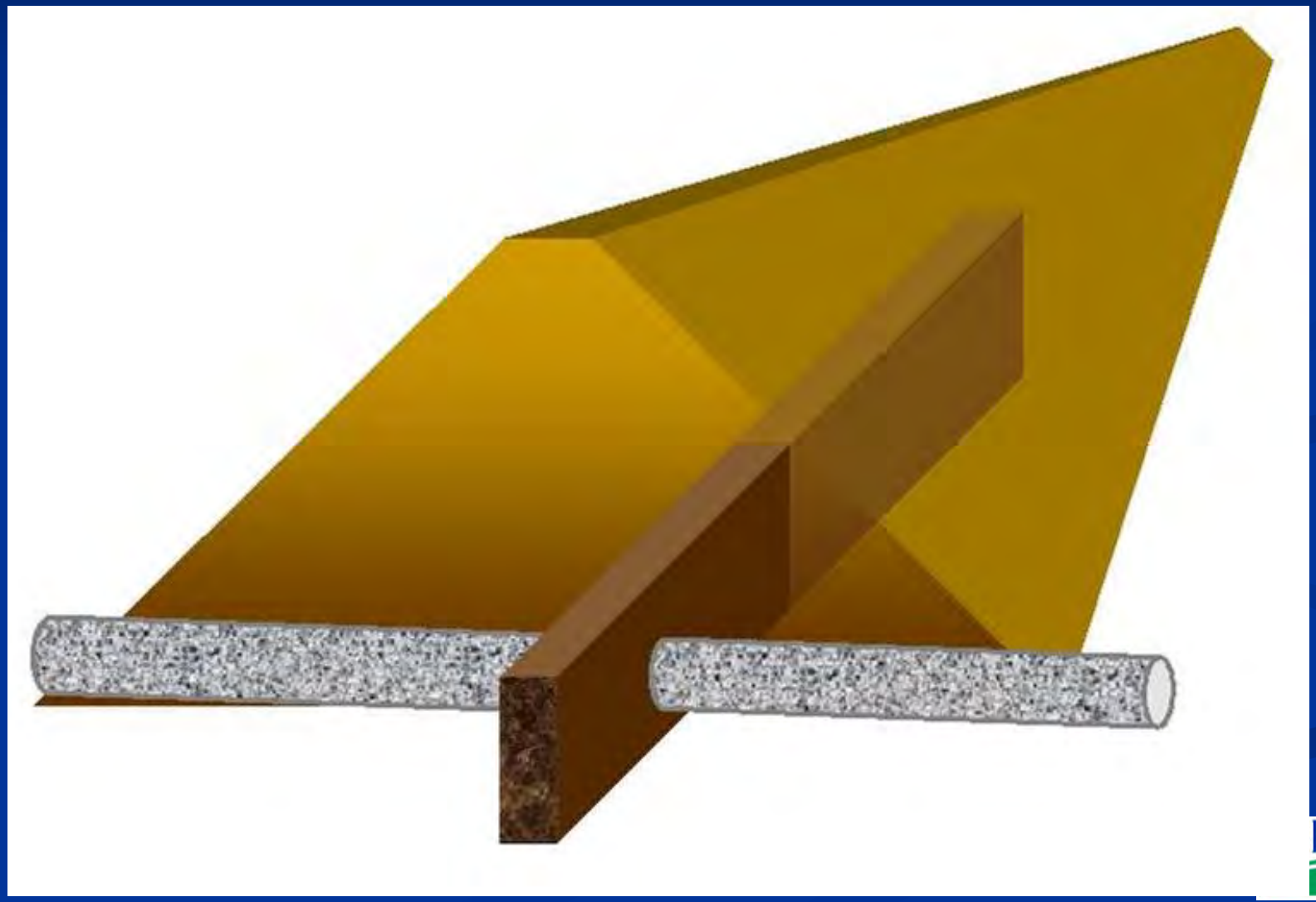
Surface Treatment

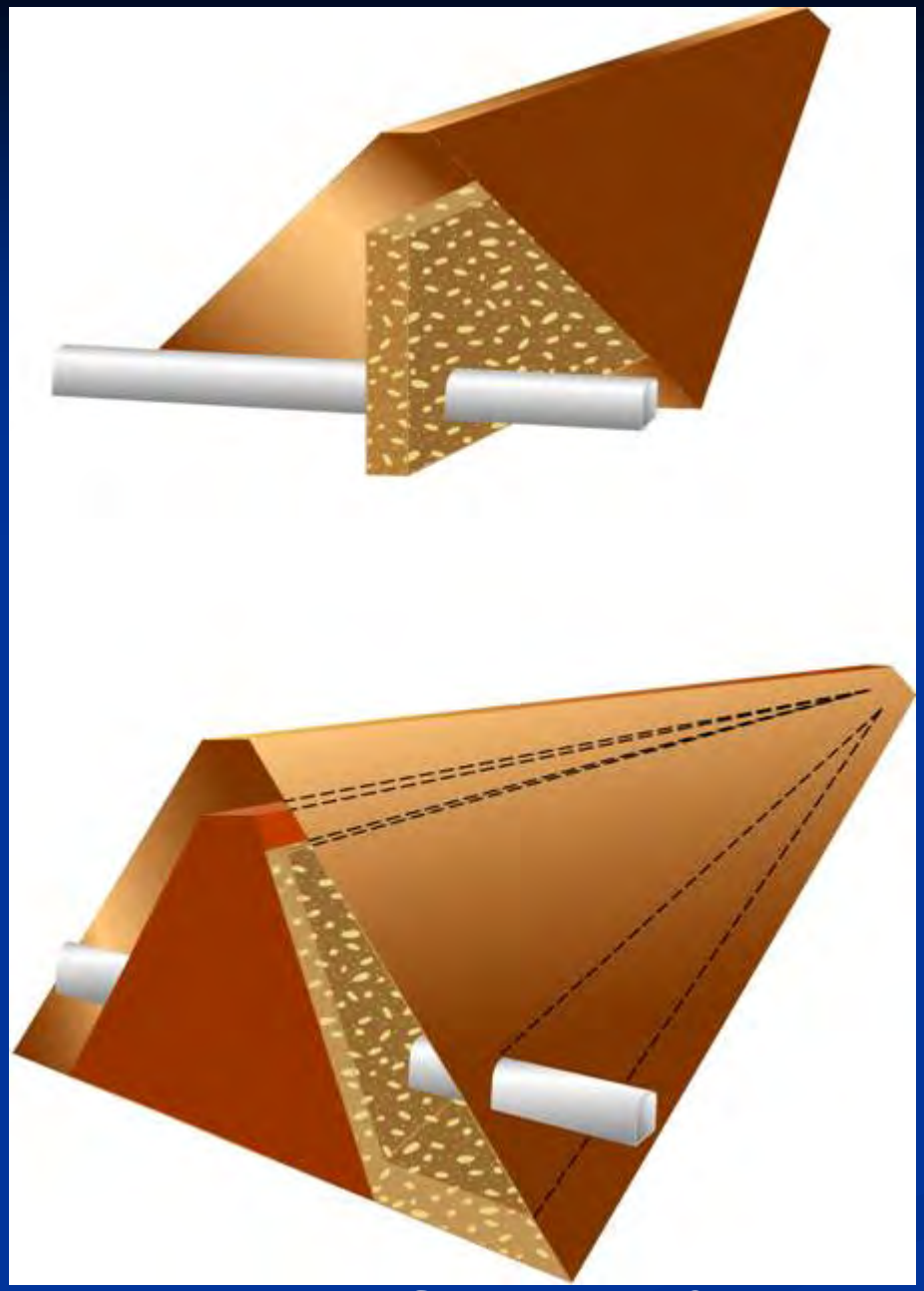


Design Measures to Combat Dispersive Clays

- Chimney Filters or Filter Diaphragms around Pipes and areas of hydraulic fracturing
- Avoid Differential Settlement
- Provide for Flexible Fill - compact wet of optimum

Chimney Filters or Filter Diaphragms around Pipes





Chimney Filters and Filter Diaphragms around Pipes

Natural Resources Conservation Service

Chemical Admixtures



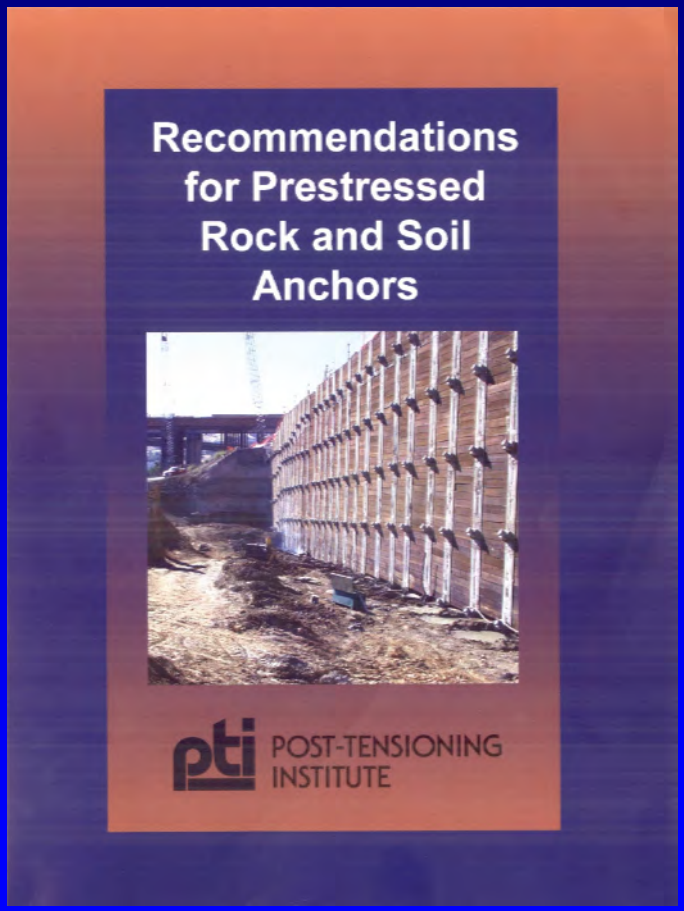
- Lime, Fly Ash, Alum Treatment
- Spread 2% hydrated or quick lime
- Incorporate with rotomixer
- Cure and place on dam

US Army Corps of Engineers
Huntington District

One Corps, One Regiment, One Team

Post-Tensioning Institute

Tri-Service Infrastructure Systems Conference



Michael McCray, P.G.
(304) 399-5234

US Army Corps of Engineers
Huntington District

Technical Revisions

- **Corrosion Protection**
- **Partially Bonded Anchors**
- **Bond Length Design**
- **Bar Anchors**
- **Supplementary Requirements for Epoxy-Coated Strand Tendons**

US Army Corps of Engineers
Huntington District

EC 1110-2-6058
31 October 2003

- **Rock Mass Shear Failure and References to PTI**

Technical Revisions

Corrosion Protection

- **Epoxy-Coated Bars**
- **Decision Tree** **(Consequences Of Failure)**
- **Corrugated**

Corrosion Protection **Epoxy-Coated Bars**

An epoxy-coated bar tendon grouted into a drill hole that has successfully passed the water pressure test is no longer considered Class I Protection



US Army Corps of Engineers
Huntington District

Corrosion Protection
Epoxy Coated Bars

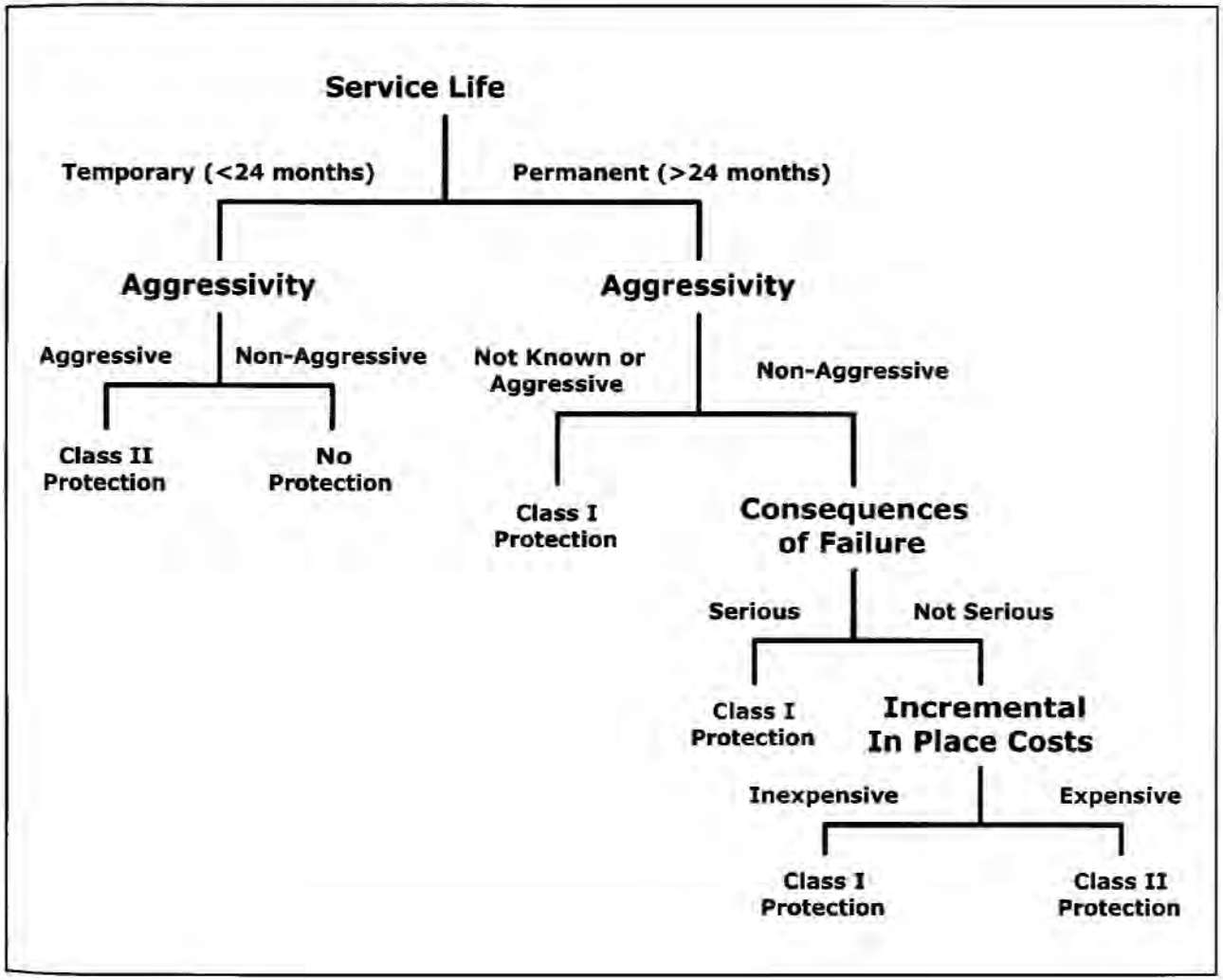
Epoxy coatings for bar and strand are not equivalent

- The average thickness required and possible on bars is only one third that of strand
- ASTM A775 and A934 allow an average of 3 holidays per lin. m of bar (without patching)
- ASTM A882 for strand allows only 2 holidays per 30 lin. m of stand (must be patched)
- The epoxy coating used on strand is more resistant to damage



Corrosion Protection
Decision Tree

Figure 5.1 Corrosion Protection Decision Tree



US Army Corps of Engineers
Huntington District

Corrosion Protection **Decision Tree**

Consequences Of Failure

Third Edition

"If the failure of an isolated anchor could result in serious consequences, then the entire tendon length shall be protected by at least one layer of protection in addition to the grout or resin regardless of the aggressivity of the ground."

Fourth Edition

"If the failure of the anchors could result in serious consequences, such as loss of life or serious economic impact, then the entire tendon length shall be protected by a Class I protection (See Section 5.3)."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Corrosion Protection **Corrugated**

‘Cutting of “windows” in the sheath or omission of the end cap in order to allow equalization of interior and exterior grout levels shall not be permitted.’

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Corrosion Protection **Corrugated**

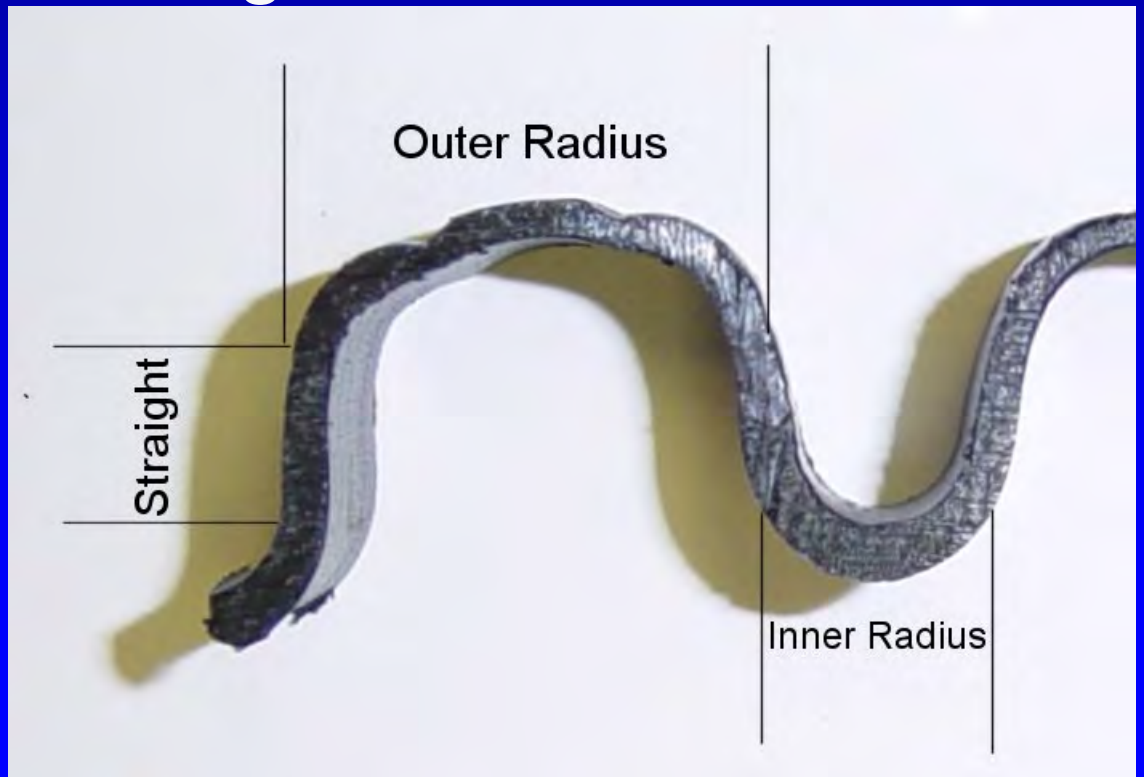
- HDPE Nominal thickness (0.060 in.)
- HDPE Minimum thickness (0.050 in.)

"A heavier wall thickness will be required for large diameter plastic tubing"

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Corrosion Protection

- **Corrugated (Prinsco, Goldline)**
  - **70-mil (measured at the crown)**
    - **84-mil max**
    - **56-mil minimum**
  - **550 ft lengths**



Corrosion Protection **Corrugated**

- Critical buckling pressure for 10” diameter, 70-mil corrugated: 19 PSI
- Critical buckling pressure for 10” diameter, 100-mil corrugated: 39 PSI

Corrosion Protection **Corrugated**

"On projects where routine water pressure testing of the drill hole is specified, pressure testing of the encapsulation after installation and prior to any grouting should be considered"

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Corrosion Protection
Corrugated



Technical Revisions

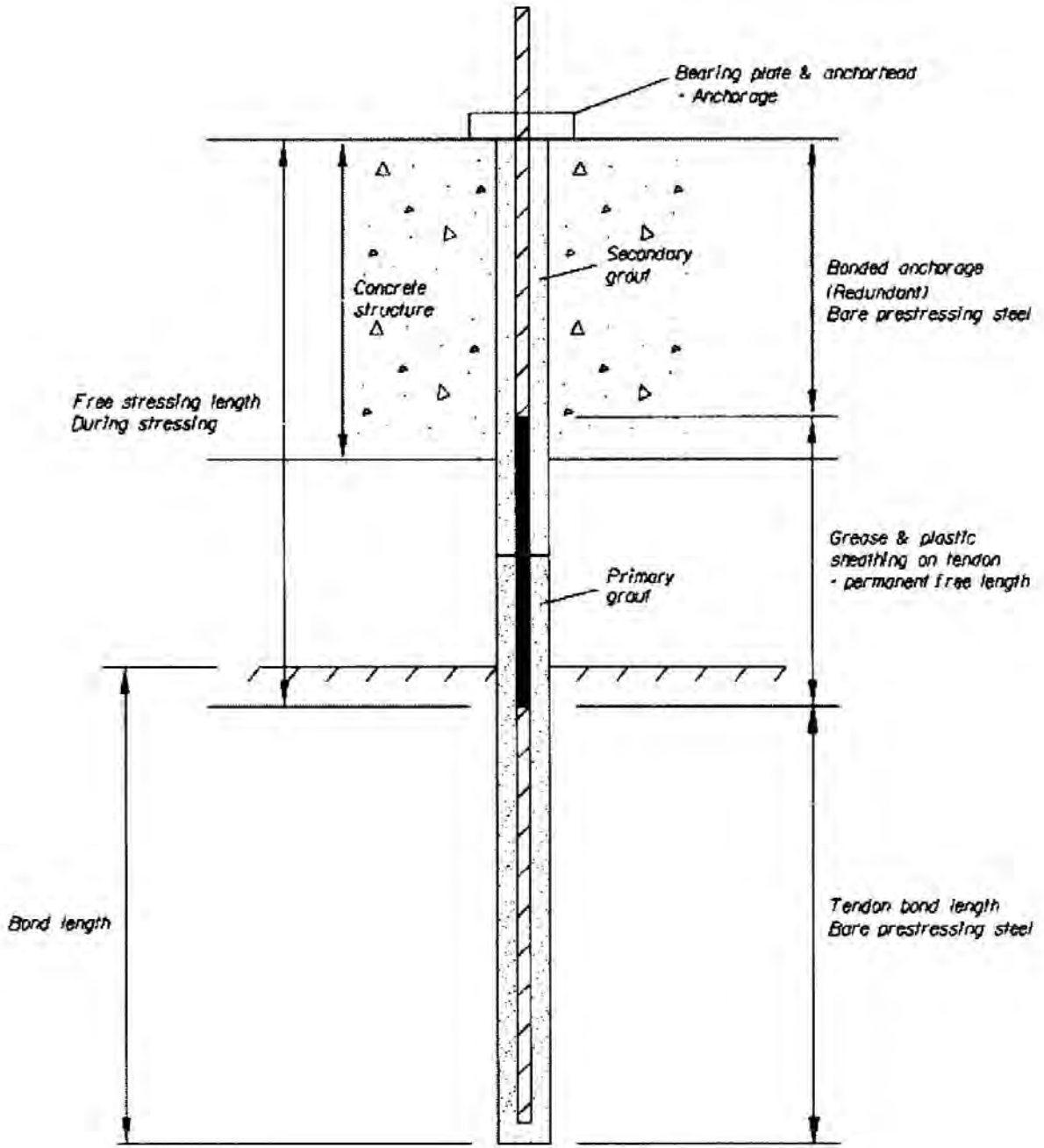
Partially Bonded Anchors

What are they?

Partially Bonded Tendon

"Partially bonded free lengths provide redundant load transfer at the anchorage while at the same time leaving a certain amount of unbonded free length."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition



Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Technical Revisions

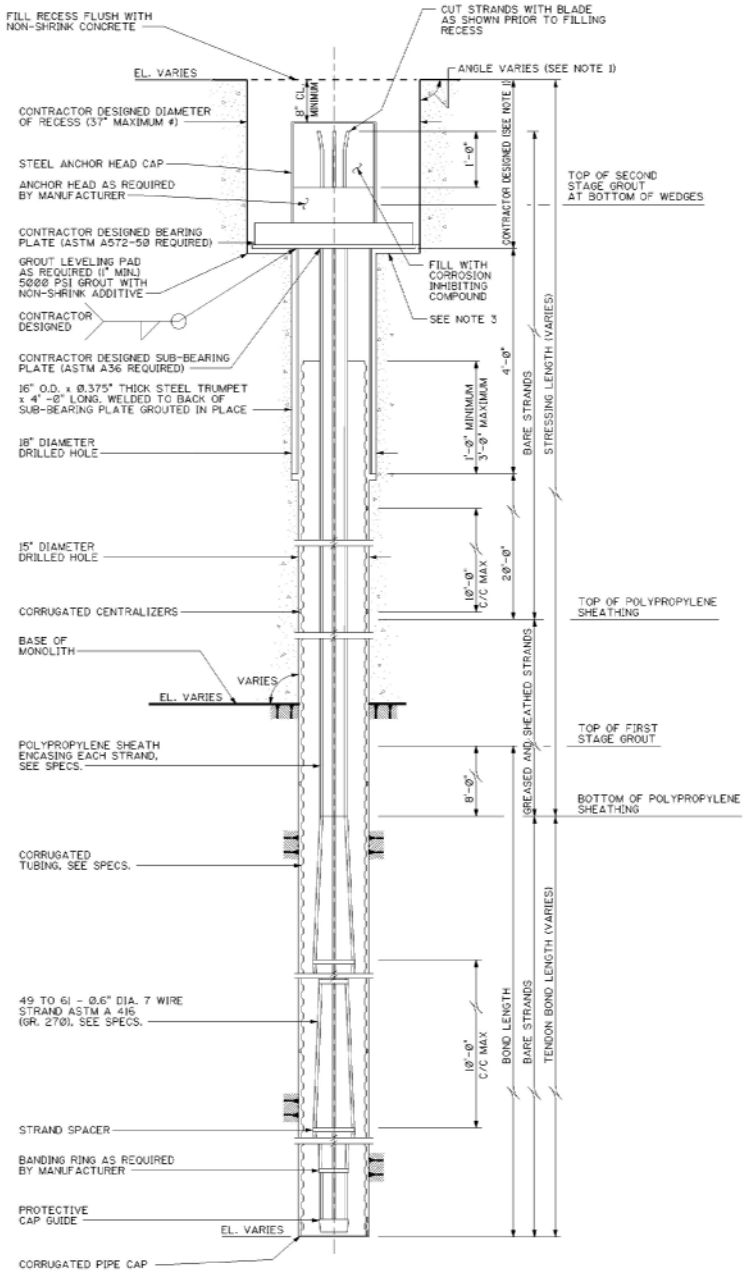
Bond Length Design

Can we increase the efficiency?

Bond Length Design

"Extending the unbonded length of the prestressing steel a sufficient depth into the bond zone so that the bond length is partially loaded in compression"

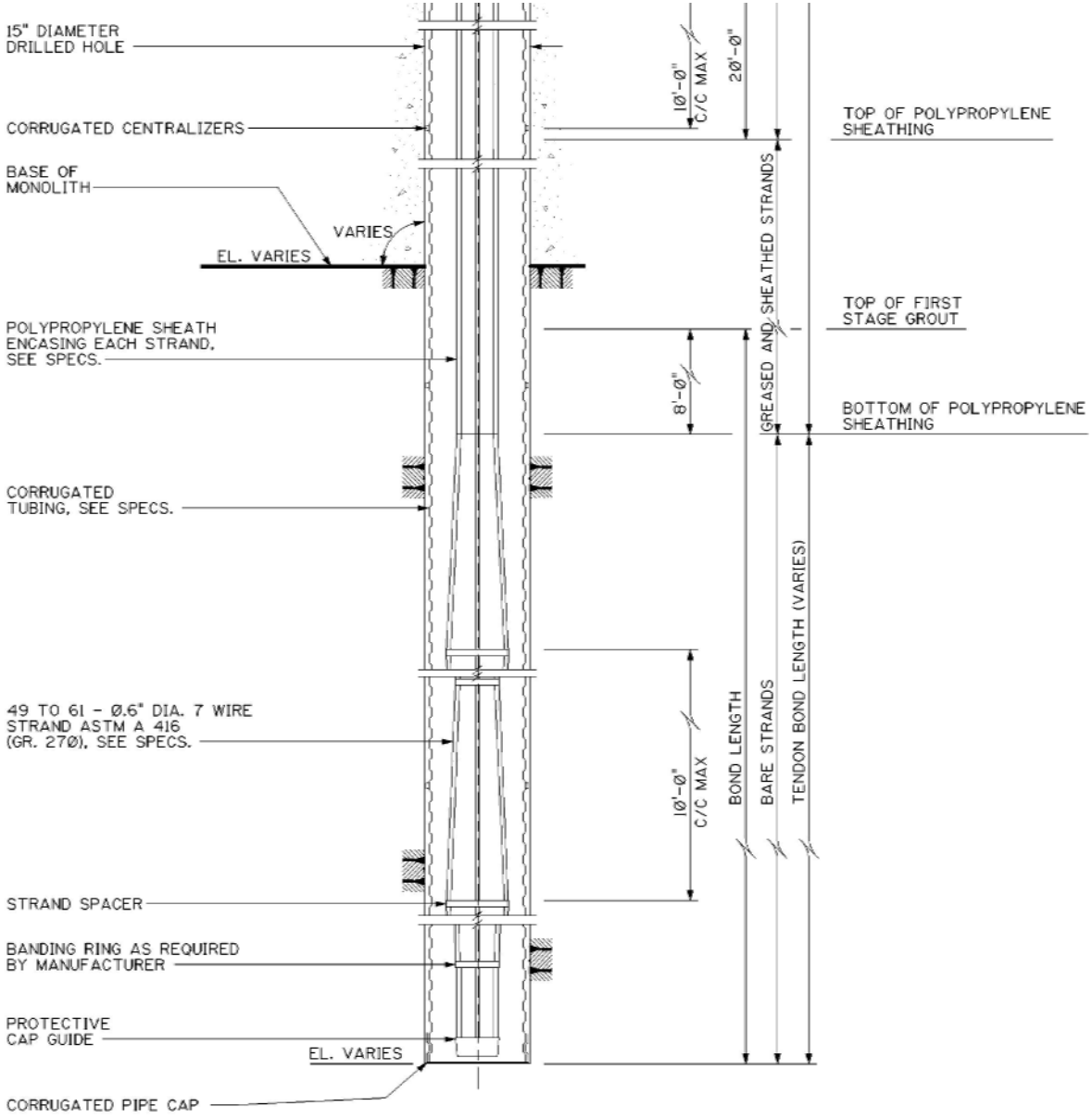
Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition



TYPICAL 49 TO 61 STRAND

NONRESTRESSABLE ANCHOR DETAIL

SCALE: 1" = 1'-0"



TYPICAL 49 TO 61 STRAND

NONRESTRESSABLE ANCHOR DETAIL

SCALE: 1" = 1'-Ø"

US Army Corps of Engineers
Huntington District

Bond Length Design

Over Grouting of the bare strand (5 to10 feet)

- Eliminates disking of the grout near the top of the bond zone
- Compensates for small grout losses
- Allows for partially bonded anchors

Technical Revisions

Bars

Are they all created equal?

Bar Anchors

"For bars that have not been proof stretched during manufacturing to $0.8F_{pu}$, creep test data shall also be submitted"

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Bar Anchors

- Threadbars up to a diameter of 1 3/8” are hot-rolled and then cold stretched (proof stretched)
  - Results in a very linear stress-strain curve to near the yield point
- Threadbars larger than 1 3/8” are cold drawn but not cold stretched
  - Because the drawing force used in the manufacturing process is much lower than the yield force the stress-strain curve is nonlinear
  - Results in:
    - Increased relaxation (ask for relaxation %)
    - Increased creep
    - Plastic behavior prior to yield

Bar Anchors

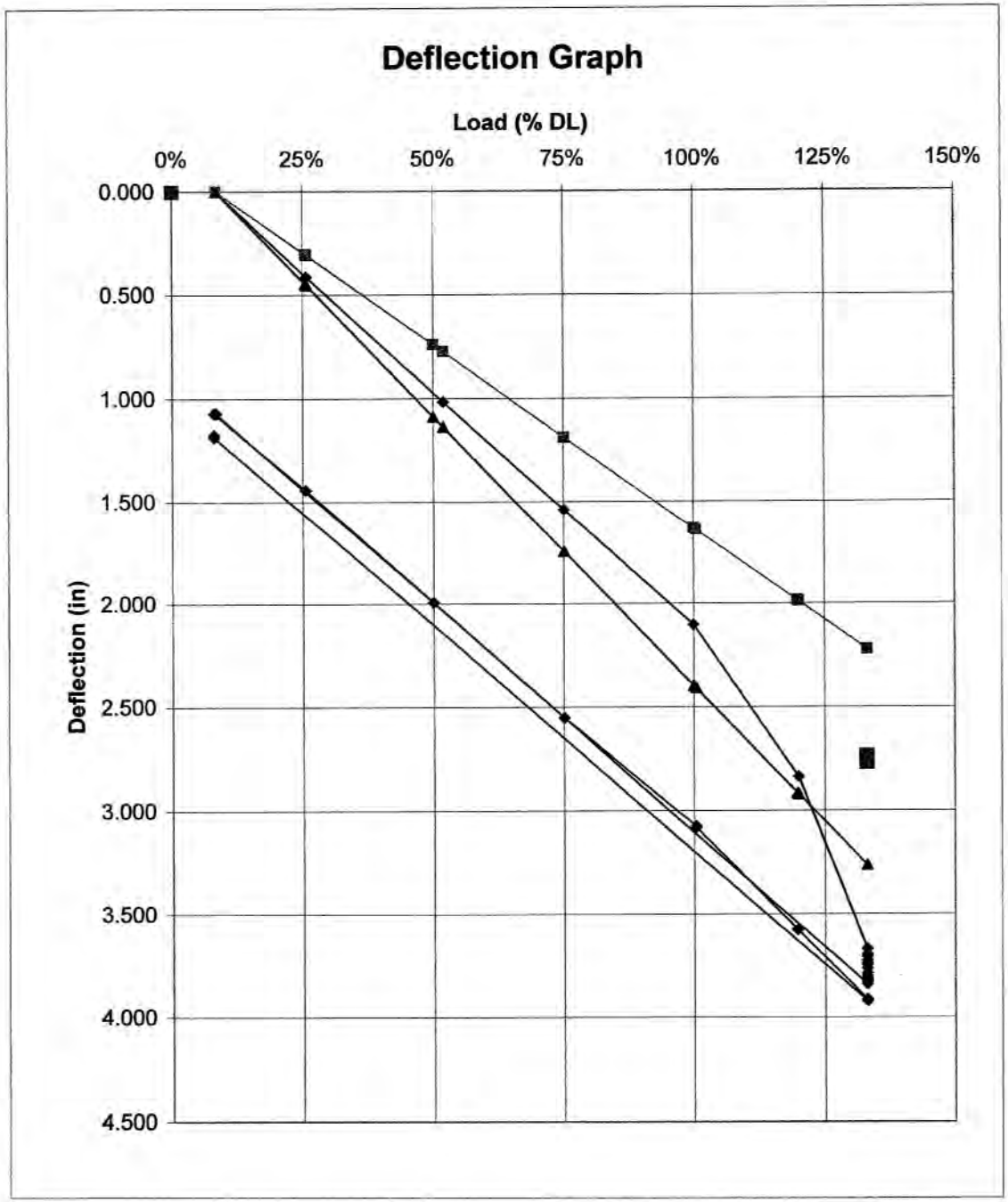
"The Creep Test is intended to determine the creep movement of the grout body through the ground at the test load."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Free Length
56.5 feet

Nicholson Construction Company
R3

Bluestone Dam Drift & Debris
Design Load: 240



Supplementary Requirements for Epoxy-Coated Strand Tendons

- **Creep**
- **Relaxation**
- **Minimum free stressing length**

Supplementary Requirements for Epoxy-Coated Strand Tendons

"Recent tests have shown that the amount of creep between strands from one manufacturer can vary by up to 50% from the average creep and between manufacturers by as much as a factor of 3."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

US Army Corps of Engineers
Huntington District

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Supplementary Requirements for Epoxy-Coated Strand Tendons

Creep Test Performed at 80% GUTS								
	Average % Creep After 10 Min		25 foot Free Length elongation in Inches		50 foot Free Length elongation in Inches		100 foot Free Length elongation in Inches		150 foot Free Length elongation in Inches
M1 Bare Strand 16 Samples	0.0057%		0.017		0.034		0.068		0.102
MAX	0.0100%		0.030		0.060		0.120		0.180
Min	0.0012%		0.004		0.007		0.015		0.022
STDEV	0.0028%		0.008		0.017		0.034		0.051
M1 Epoxy Strand 21 Samples	0.0092%		0.028		0.055		0.110		0.165
MAX	0.0171%		0.051		0.103		0.205		0.307
Min	0.0042%		0.013		0.025		0.050		0.075
STDEV	0.0034%		0.010		0.020		0.040		0.060
M2 Bare Strand 4 Samples	0.0067%		0.020		0.040		0.080		0.120
MAX	0.0100%		0.030		0.060		0.120		0.180
Min	0.0050%		0.015		0.030		0.060		0.090
STDEV	0.0023%		0.007		0.014		0.027		0.041
M2 Epoxy Strand 26 Samples	0.0248%		0.074		0.149		0.297		0.446
MAX	0.0421%		0.126		0.253		0.505		0.758
Min	0.0163%		0.049		0.098		0.195		0.293
STDEV	0.0067%		0.020		0.040		0.081		0.121
Note: Those samples tested to 70% were not included.									

Supplementary Requirements for Epoxy-Coated Strand Tendons

	OPTIONS	DESIGN LOAD (F_{pu})	CREEP CRITERIA	TEST LOAD as % of F_{pu}	COMMENTS
1	Test to 1.5 DL	0.53	None	80	No Creep Test is conducted
2	Test to 1.33 DL	0.53	Same as bare strand	70	Limited test data suggest creep for epoxy-coated strand at this stress level is similar to bare strand
3	Test to 1.33 DL and conduct subsequent Lift-off Tests	0.60	None	80	Lift-off must be at least the original load minus the predicted tendon relaxation

Supplementary Requirements for Epoxy-Coated Strand Tendons

"In defining the design load, the higher relaxation in epoxy-coated strand should be considered. The relaxation of epoxy-coated strand can be as high as 6.5% in 1,000 hours at $0.7F_{pu}$, compared to 2.5% for bare strand.

Both creep and relaxation are the results of plastic deformation in the strand under load."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

Supplementary Requirements for Epoxy-Coated Strand Tendons

"A longer free stressing length is required for epoxy-coated strand to compensate for higher wedge seating loss, typically 15 to 25 mm (5/8 to 1 in.), versus 3 to 12 mm (1/8 to 3/8 in) for bare strand."

Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

US Army Corps of Engineers
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EC 1110-2-6058
31 October 2003

Rock Mass Shear Failure and References to PTI

EC 1110-2-6058
31 October 2003

(3) Rock-mass shear failure

(a) Tensioned structural anchors. With all tensioned structural-anchor systems, a major consideration is determining how deep to install the anchors. An anchor system that is too shallow may cause tension and cracking to occur along potential failure planes in the foundation, and a system too deep is uneconomical. PTI recommends normal bond length not less than 3.0m (10ft) for bars and 4.5m (15ft) for strand. Bond lengths greater than 10m (35ft) are normally not used. PTI recommends free stressing lengths to be at least 3.0m (10ft) for bar tendons and 4.5m (15ft) for strand tendons. Center-to-center spacings between anchors shall be at least 1.5m (5ft) unless unusual circumstances dictate. The fixed end (dead end) anchorages should be staggered.

EC 1110-2-6058
31 October 2003

Post-Tensioning Institute, “Recommendations for Prestressed Rock and Soil Anchors”, does not give guidance on determining how deep to install the anchors.

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Huntington District

Anchor Depth Design

"When selecting the elevation of the top of the bond length, the designer must consider the resistance to pullout of the rock mass, which also governs anchor length." PTI

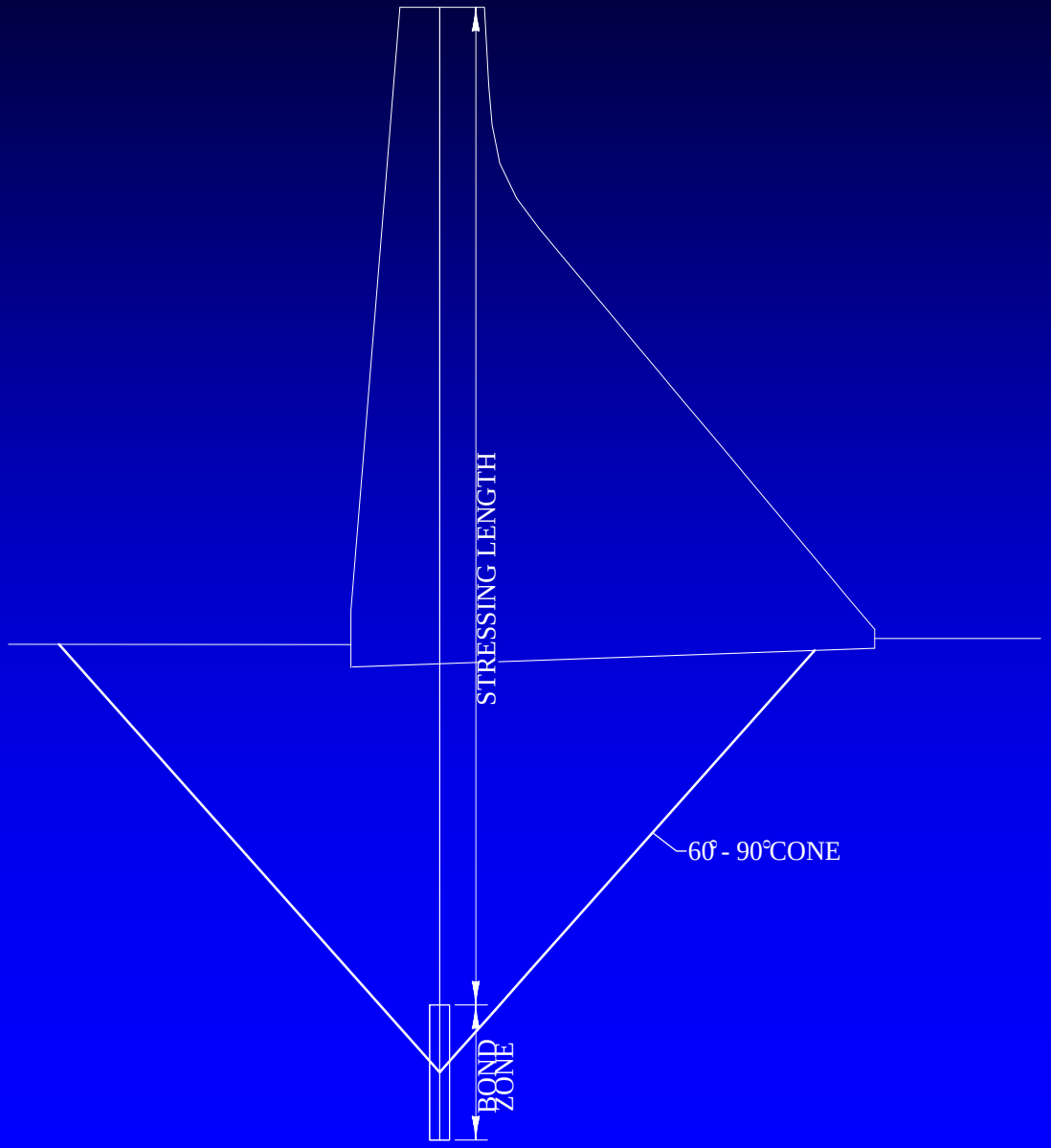
Post-Tensioning Institute, Recommendations for Prestressed Rock and Soil Anchors, Fourth Edition

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Huntington District

Anchor Depth Design

"The anchor depth is taken as the anchor length necessary to develop the anchor force required for stability." EM 1110-1-2908

US Army Corps
of Engineers
Huntington District



US Army Corps of Engineers
Huntington District

Anchor Depth Design

EM 1110-1-2908 gives 2 formulas for competent rock:

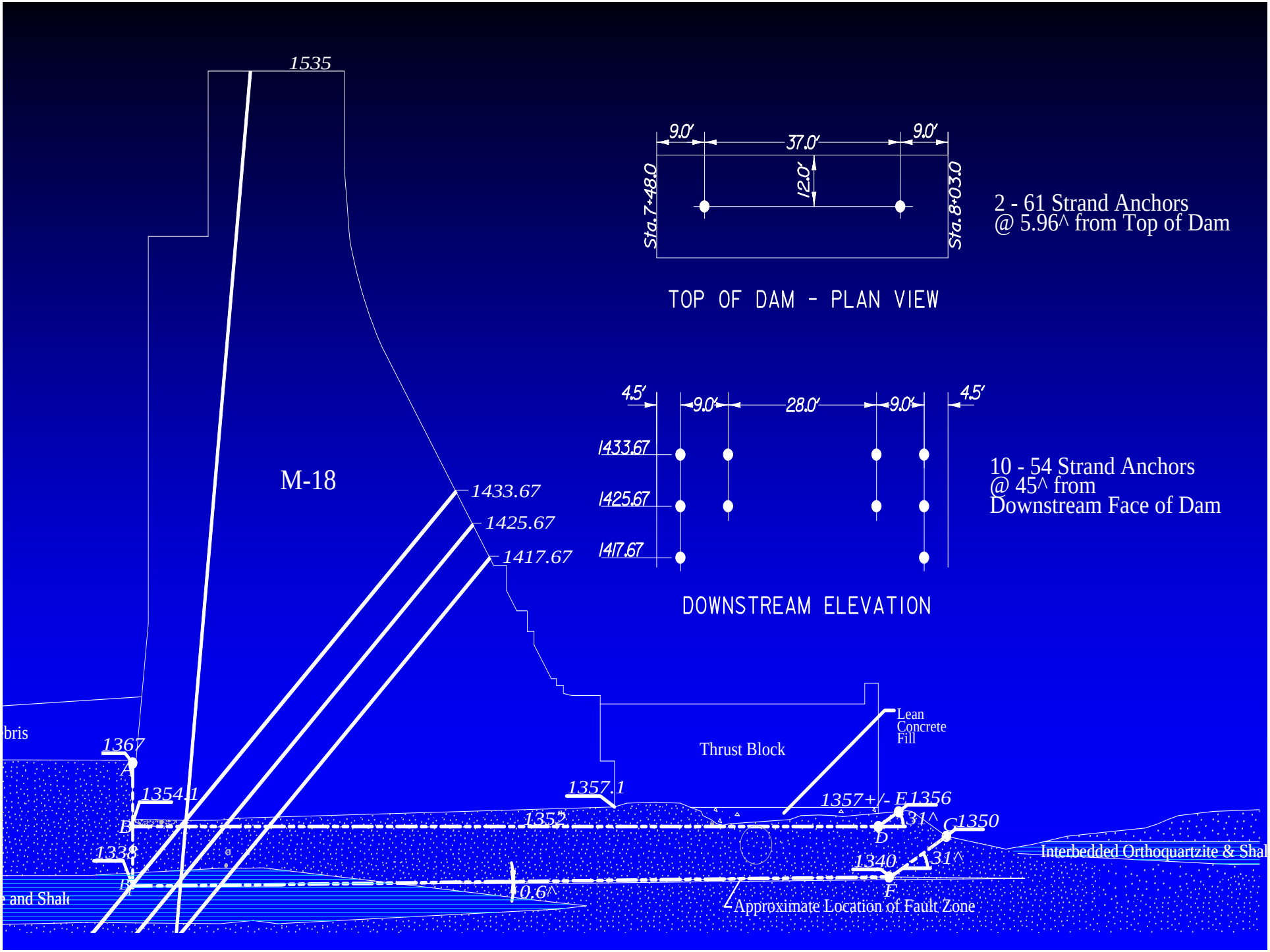
1. **Single Anchor in Competent Rock**
2. **Single Row of Anchors in Competent Rock**

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Anchor Depth Design

EM 1110-1-2908 gives 3 formulas for fractured rock:

1. **Single Anchor in Fractured Rock**
2. **Single Row of Anchors in Fractured Rock**
3. **Multiple Row of Anchors in Competent or Fractured Rock**


1535
M-18
1433.67
1425.67
1417.67
9.0'
37.0'
9.0'
12.0'
Sta.7+48.0
Sta.8+03.0
TOP OF DAM - PLAN VIEW
2 - 61 Strand Anchors
@ 5.96^ from Top of Dam
4.5'
9.0'
28.0'
9.0'
4.5'
1433.67
1425.67
1417.67
DOWNSTREAM ELEVATION
10 - 54 Strand Anchors
@ 45^ from
Downstream Face of Dam
Thrust Block
Lean
Concrete
Fill
1367
A
1354.1
B
1338
B'
1357.1
1352
1357+/- E1356
31^
C1350
D
1340
31^
F
0.6^
Approximate Location of Fault Zone
Interbedded Orthoquartzite & Shal

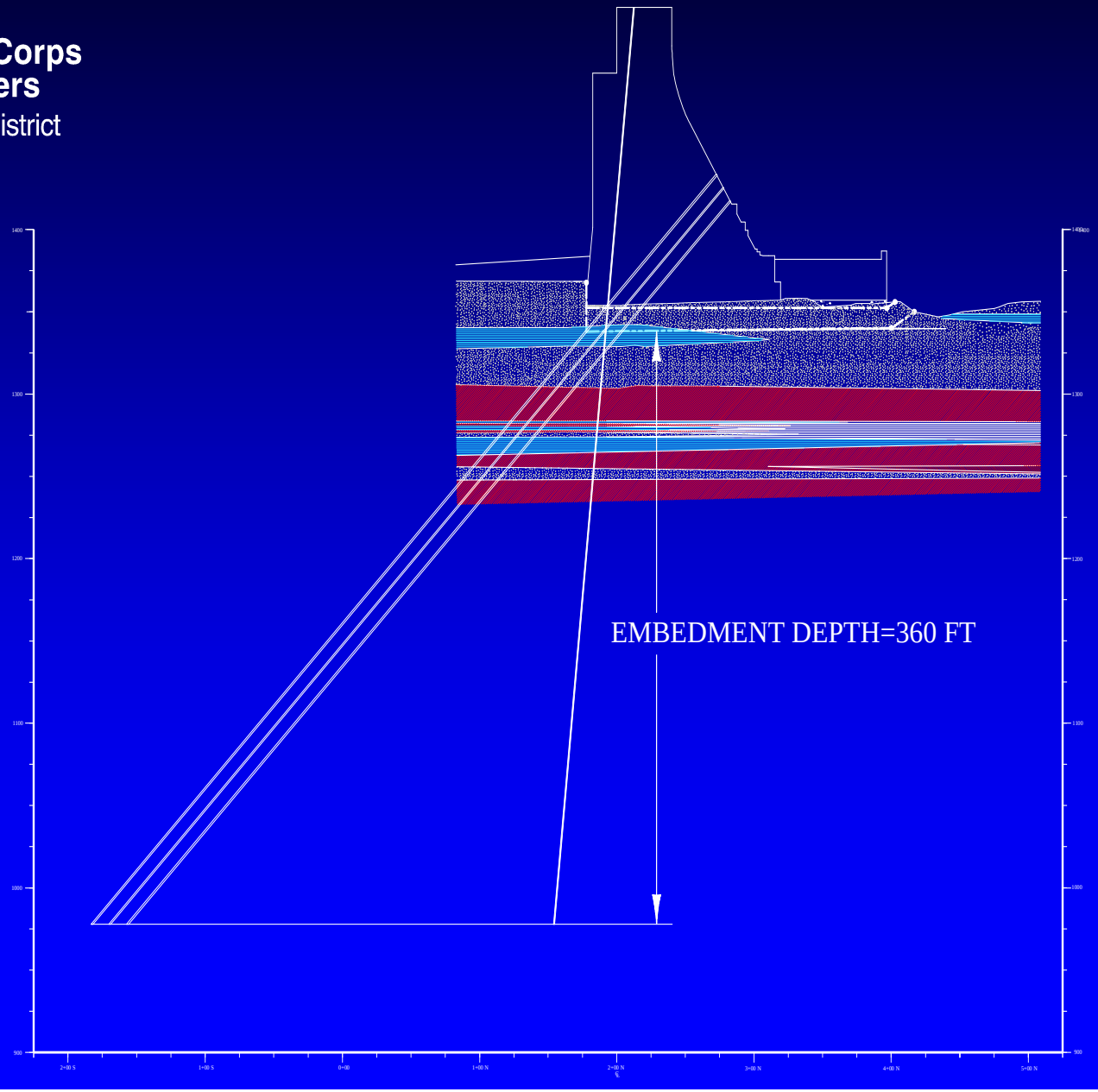
Anchor Depth Design Mon-18

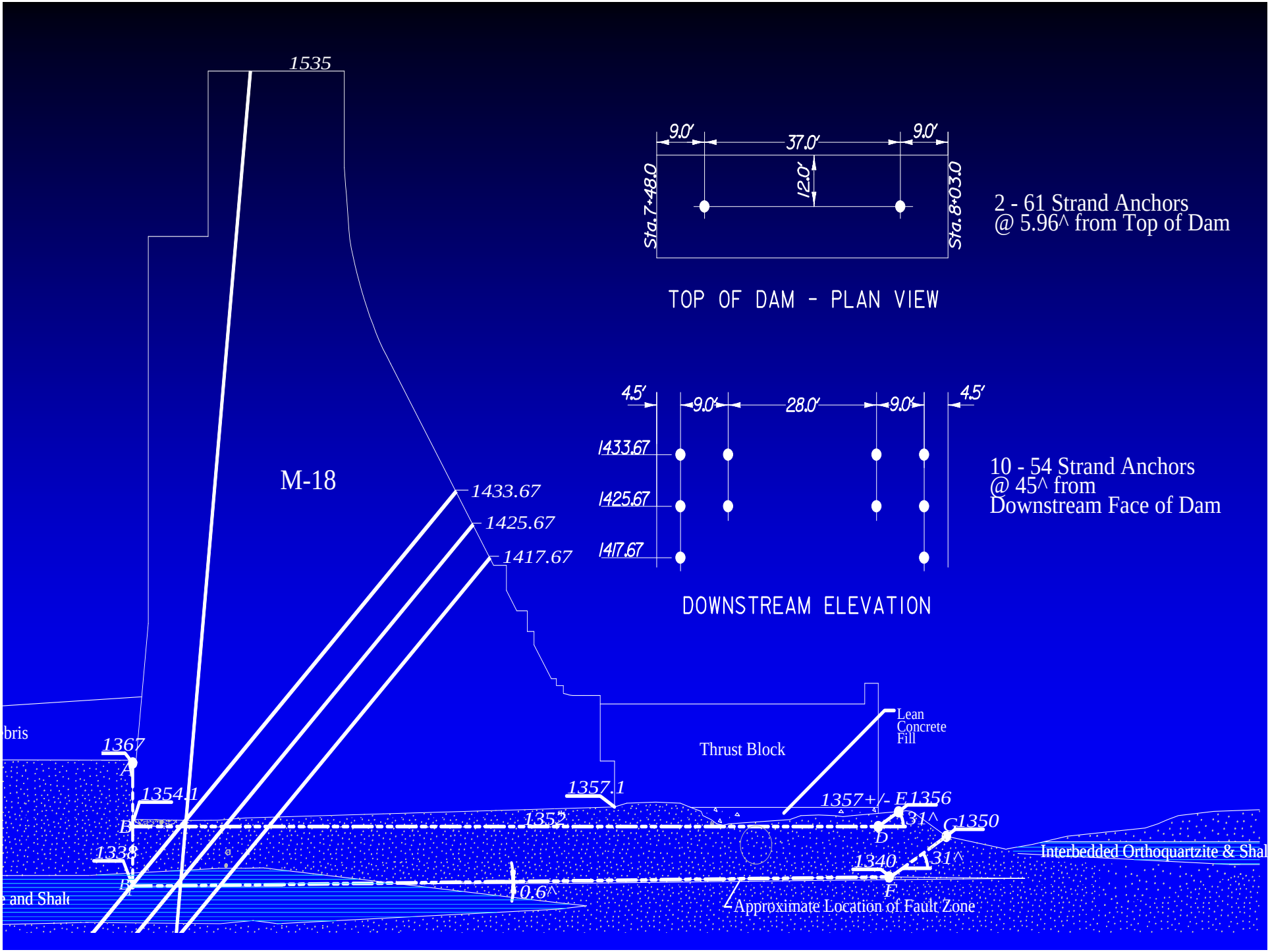
Multiple rows of anchors in competent rock, with a factory of safety of 1.5

(FS*F)/yls = Suggested depth of anchor for overall cone stability

360 feet

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Huntington District




1535
M-18
1433.67
1425.67
1417.67
9.0'
37.0'
9.0'
12.0'
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TOP OF DAM - PLAN VIEW
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1357.1
1352
1357+/- E1356
31^
C1350
D
1340
31^
F
0.6^
Approximate Location of Fault Zone
Interbedded Orthoquartzite & Shal

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Huntington District

Anchor Depth Design Mon-18

single anchor in fractured rock with the combined design load of all the anchors in that area

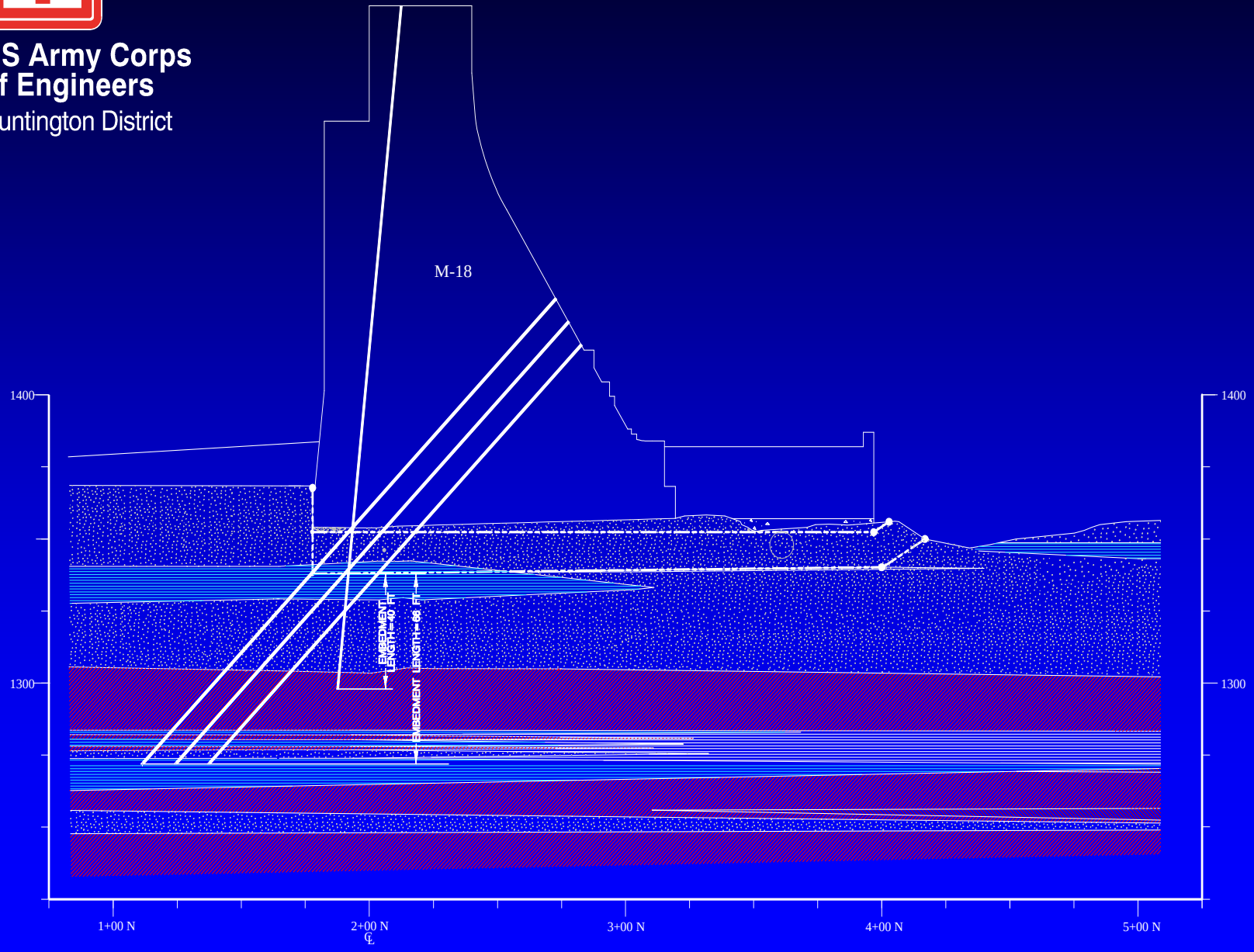
cbrt((3FS*F)/(w*3.14159))

65.3 feet

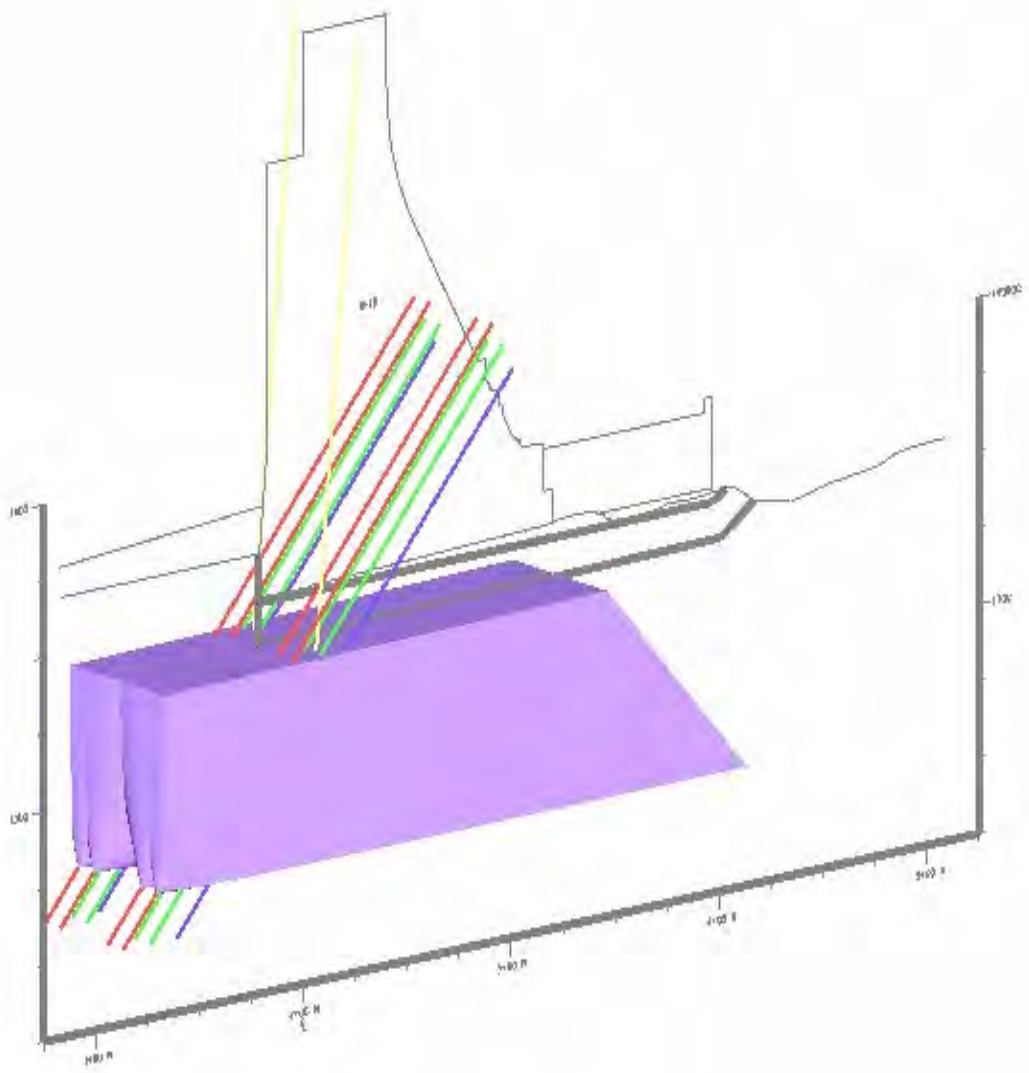
19,008,000 pounds of anchor force

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Huntington District



3-D CADD Drawing of Anchor Failure Cones Mon-18



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Huntington District

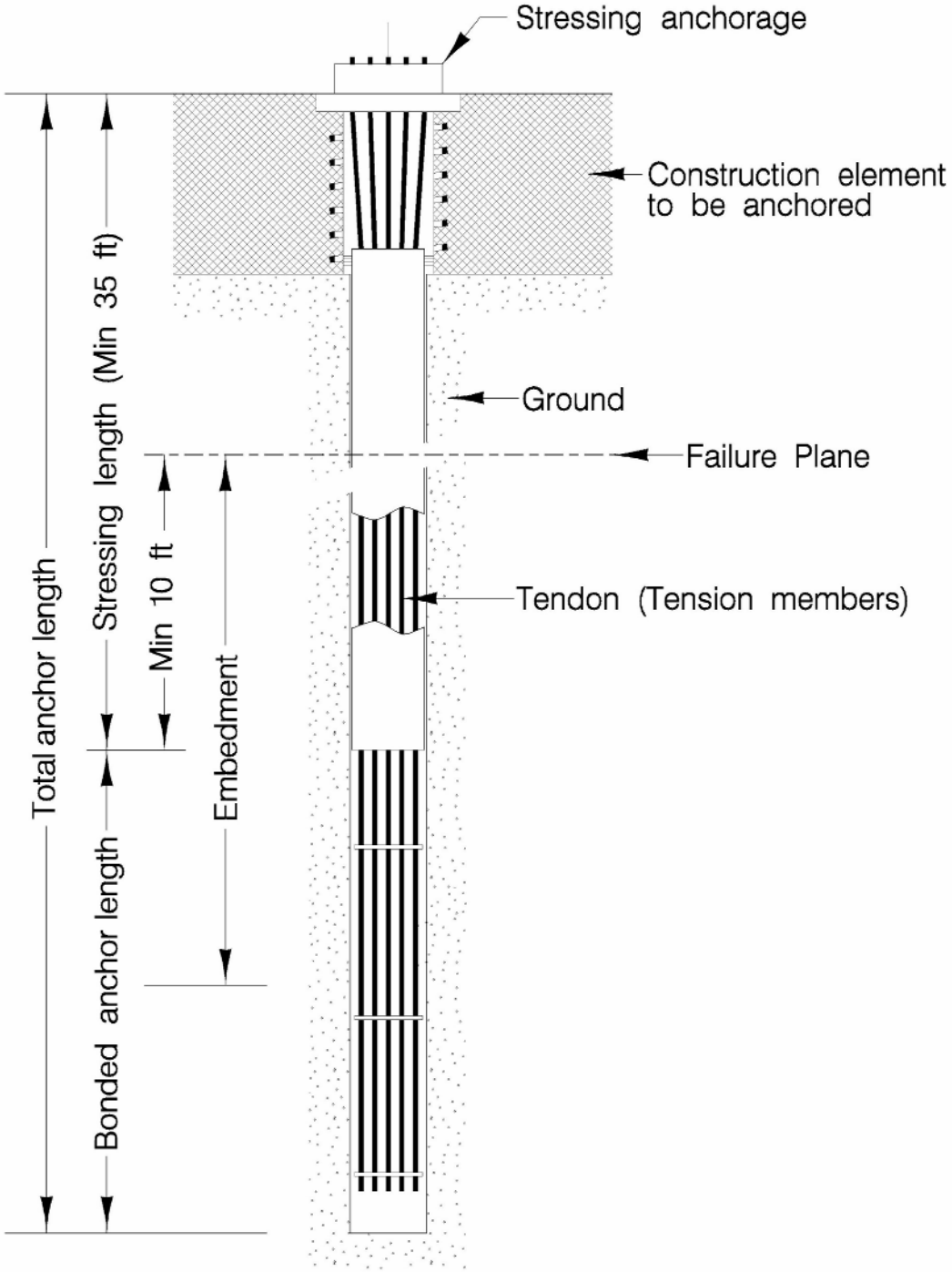
Anchor Depth Design

The buoyant weight of the rock mass engaged by the anchors in monolith 18 is 3.75 times that needed to resist the total force of the anchors.

US Army Corps
of Engineers
Huntington District

Questions ?

Michael McCray
Phone (304) 399-5234
E-mail mikem@mail.orh.usace.army.mil


Stressing anchorage
Construction element to be anchored
Ground
Failure Plane
Tendon (Tension members)
Total anchor length
Stressing length (Min 35 ft)
Min 10 ft
Embedment
Bonded anchor length

US Army Corps
of Engineers
Louisville District

Rough River Dam Safety Assurance Project

2005 Tri-Service Infrastructure Systems Conference
St. Louis, Missouri

Timothy M. O'Leary, P.E.
Senior Civil Engineer
U.S. Army Corps of Engineers
Louisville District

Presentation Outline

- Tangled Web of Intangibles
- Brief Project Overview and History
- Dam Safety Assurance Project
- Consequences of Dam Failure
- Project Status and Conclusions

Objective

"Our emphasis continues to be public safety and to minimize public inconvenience."

Reality

"Our emphasis continues to be public safety and to minimize public inconvenience."

"You can please half of the people some of the time, and some of the people half of the time, but all of the people none of the time."

Stakeholders

- Project Operations Personnel
- State Resort Park and Golf Course
- State Highway Department
- Old Grist Mill at Green Farm Resort
- Politicians, Tourism, Chamber of Commerce
- Local Residents and Recreational Visitors
- Old Time Fiddlers Contest
- Environmental Activists

US Army Corps of Engineers
Louisville District

CIVIL WORKS PROJECTS



VICINITY MAP

ILLINOIS
INDIANA
INDIANA
OHIO
SALAMONIE LAKE
J. EDWARD ROUSH LAKE
MISSISSINEWA LAKE
URBANA
CECIL M. HARDEN LAKE
CLARENCE J. BROWN DAM & RESERVOIR
SPRINGFIELD
DAYTON
INDIANAPOLIS
BROOKVILLE LAKE
CAESAR CREEK LAKE
CAGLES MILL LAKE
CHARLESTON
WEST FORK LAKE
CINCINNATI
MONROE LAKE
WILLIAM H. HARSHA LAKE
MARKLAND L&D
PATOKA LAKE
MCALPINE L&D
FRANKFORT
CAVE RUN LAKE
NEWBURGH L&D
LOUISVILLE
LEXINGTON
EVANSVILLE
JOHN T. MYERS L&D
CANNELTON L&D
TAYLORSVILLE LAKE
ROUGH RIVER LAKE
NOLIN RIVER LAKE
CARR CREEK LAKE
OLMSTED L&D
SMITHLAND L&D
GREEN RIVER LAKE
HAZARD
BUCKHORN LAKE
PADUCAH
BOWLING GREEN
BARREN RIVER LAKE
KENTUCKY
TENNESSEE
N

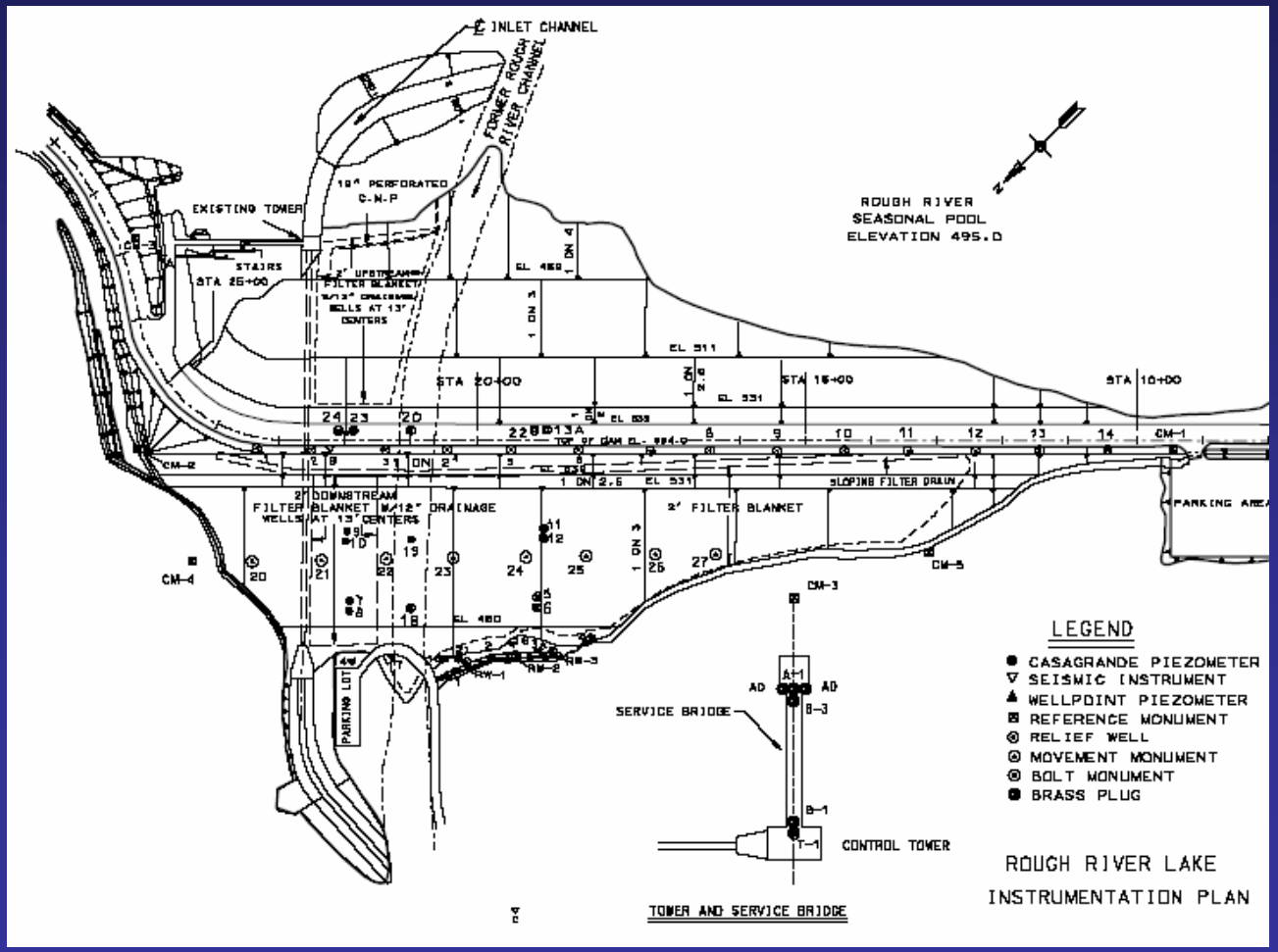
Project Overview



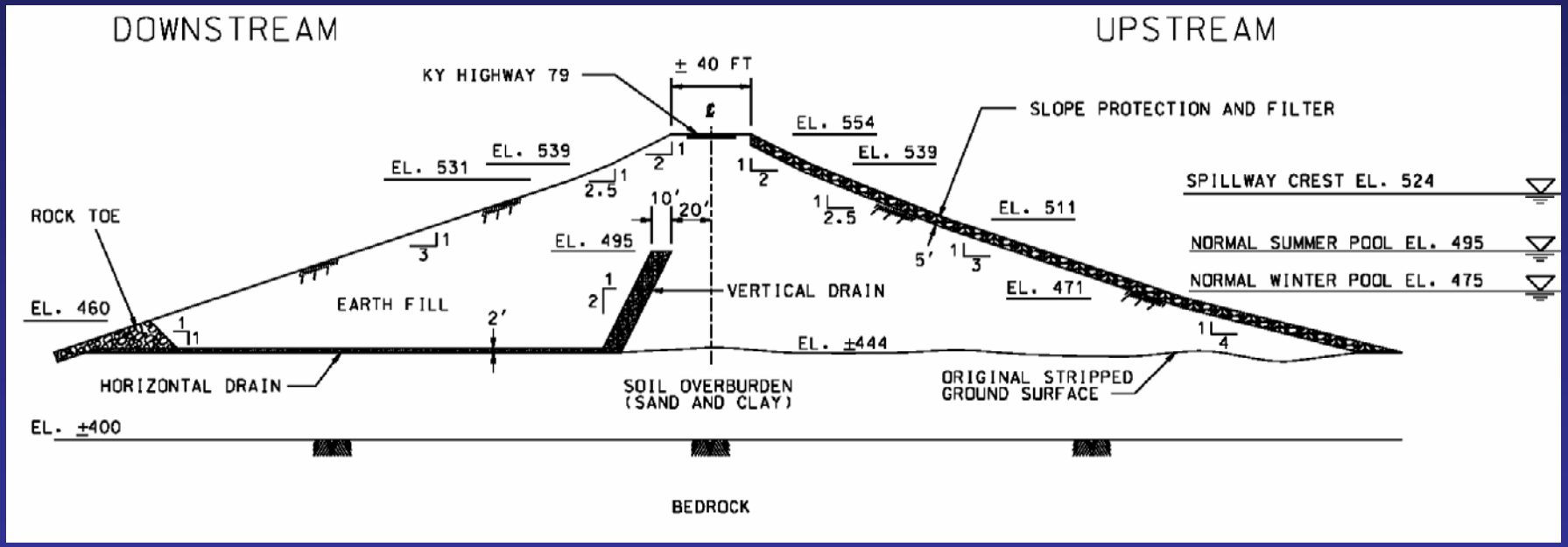
Overview of Dam



Instrumentation Plan



Typical Existing Cross-Section



Existing Slopes





Project History

- 1955: Construction begins
- 1957: Extensive damage to outlet bucket and channel during flood releases
- 1958: Construction complete
- 1960: Complete flood control operational
- 1971: First Periodic Inspection; erosion and damages noted to channel and apron
- 1975: Damage to apron

Project History (cont.)

- 1979: Extensive erosion damage to channel and apron; deep scour hole
- 1984: Severe apron and channel damage (88 CY)
- 1985: Apron undermining and erosion
- 1989: Record pool; two apron repairs (28+ CY)
- 1991: Two apron repairs (13 CY and 6 CY)
- 1993: Apron damage

Project History (cont.)

- 1998: Apron undermining and failure
- 2002: Sinkhole on downstream slope
- 2003: DSA geotechnical investigation
- 2004: “Short-term” repairs to paved apron; DSAP Evaluation Report

Dam Safety Assurance Project



Spillway Inadequacy

Existing Spillway

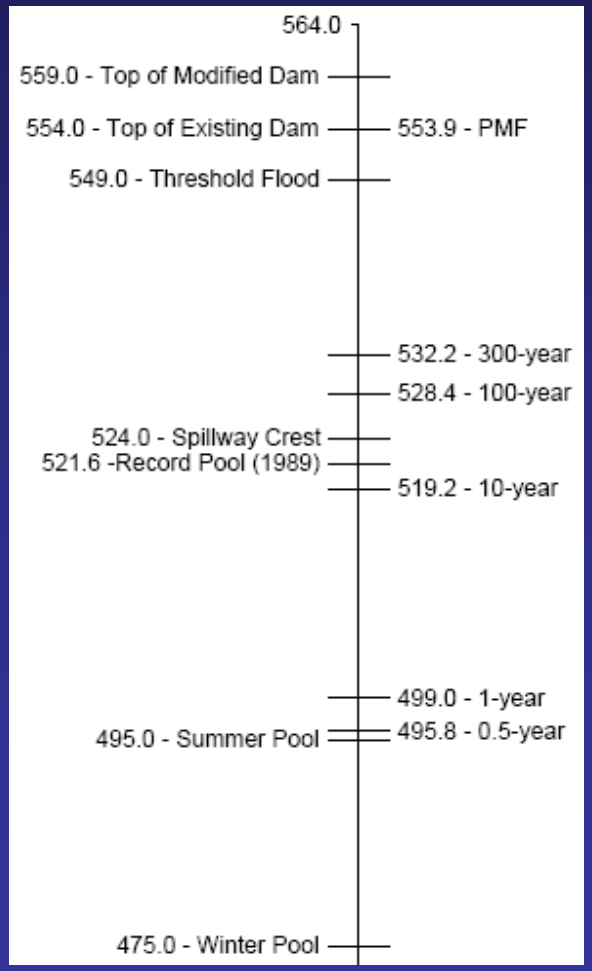


Looking Upstream from KY 79 Bridge



Looking Downstream at KY 79 Bridge

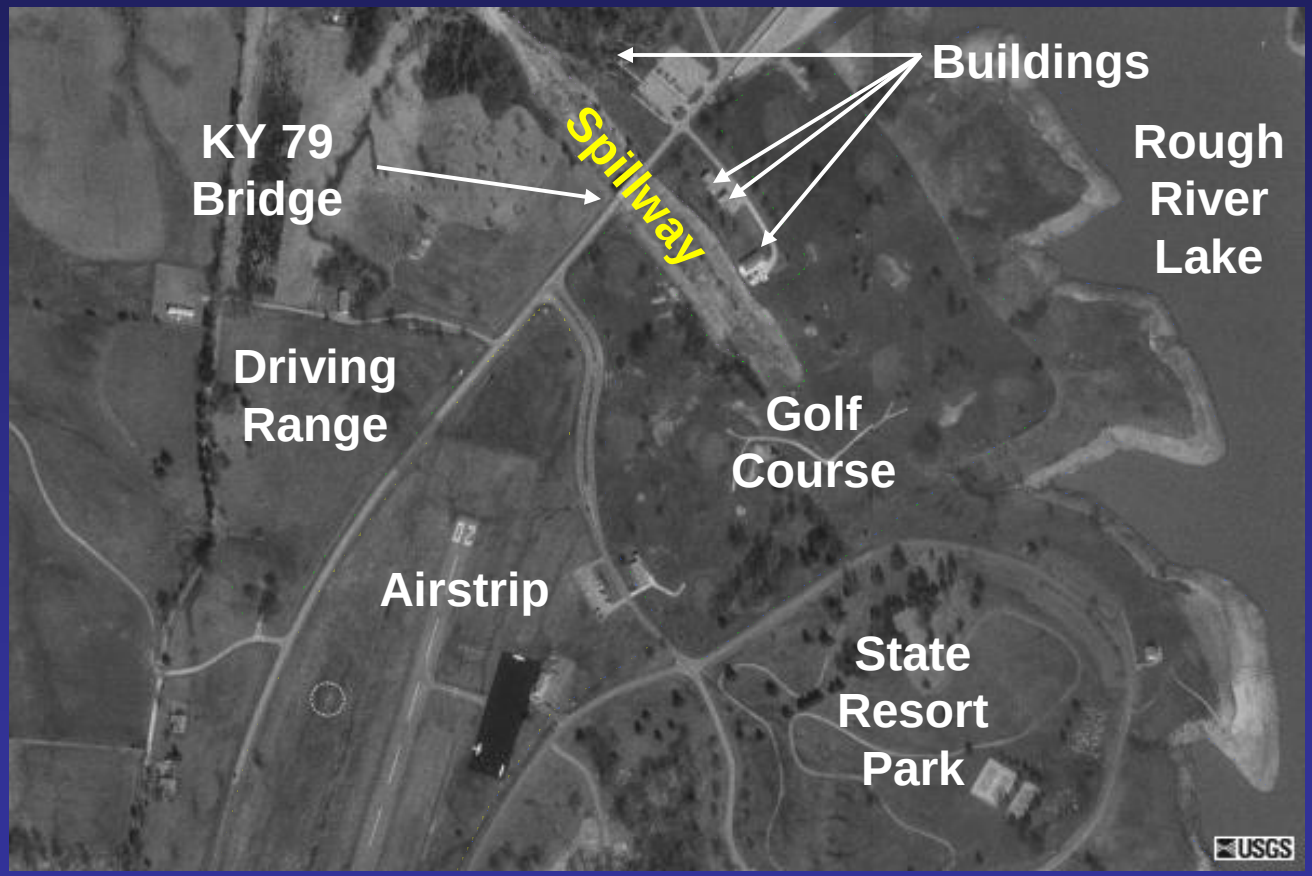
Pool Frequency Data



- PMF Elevation = TOD
- Threshold Flood = 87% PMF
- Required Freeboard = 5 feet
- BSC = 100% PMF

- No spillway events to-date
- Record Pool = 521.6 feet

Spillway Vicinity



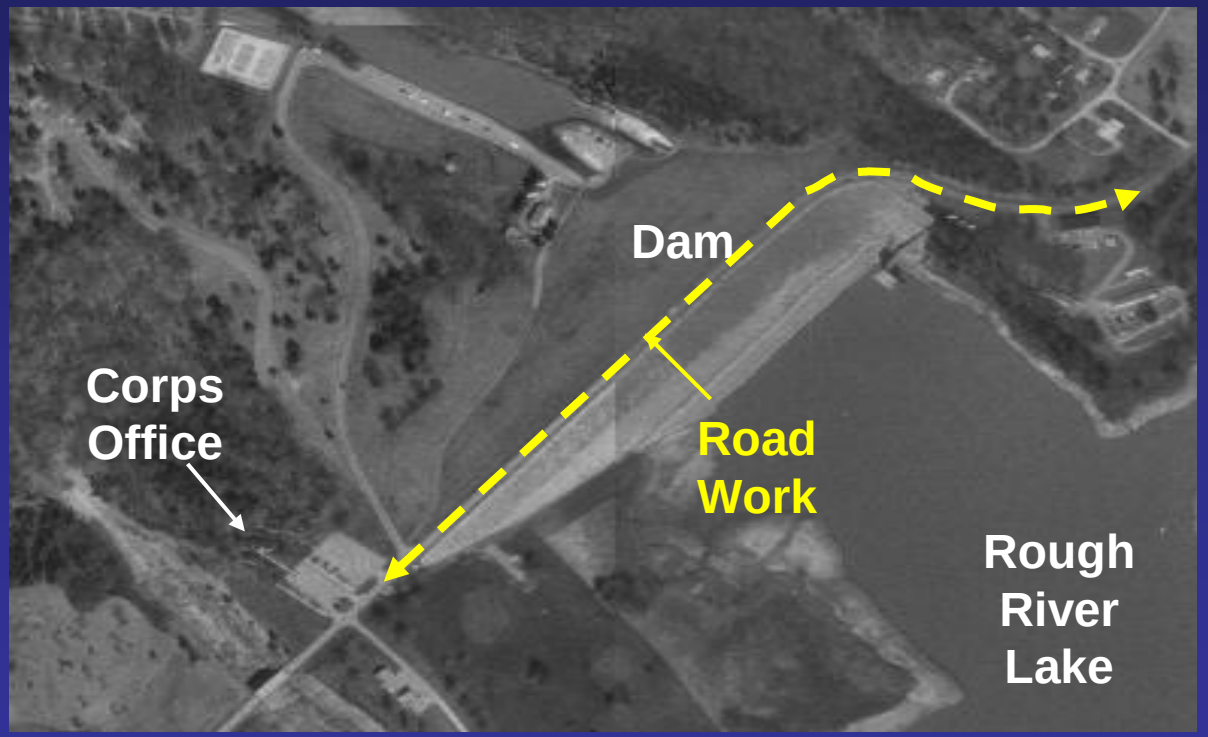
Spillway Remediation: Options

- Widen spillway by 85 feet to left or right
- Deepen spillway by 20 feet; add gates
- ➢ Raise dam crest by 5 feet with earth fill, parapet wall, inflatable dam or other mechanical-gated structure, or a combination of these options

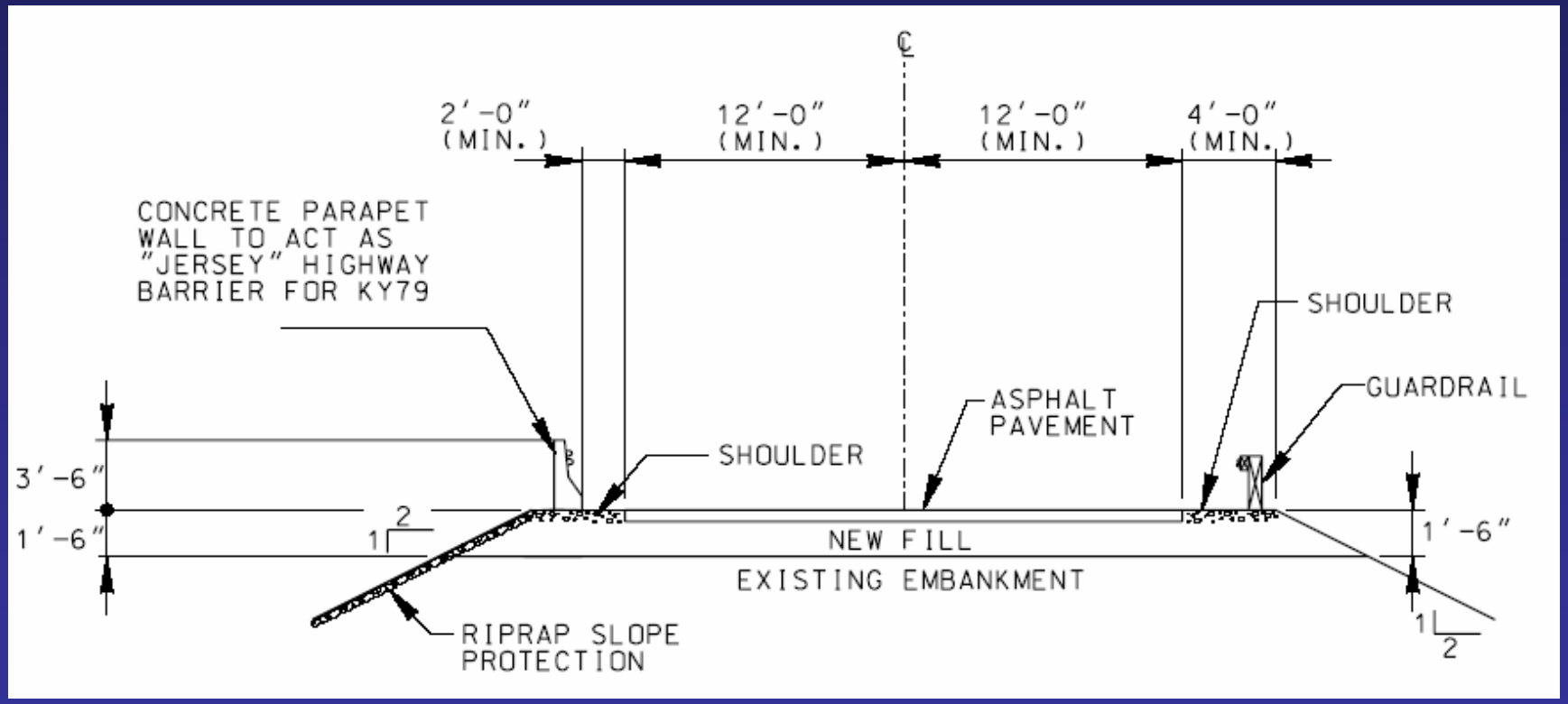
Spillway Remediation

Construct 3.5′ tall parapet wall along upstream crest of dam to meet KDOH standards

Raise road ±1.5′



New Dam Crest Geometry



Rock Toe Repair

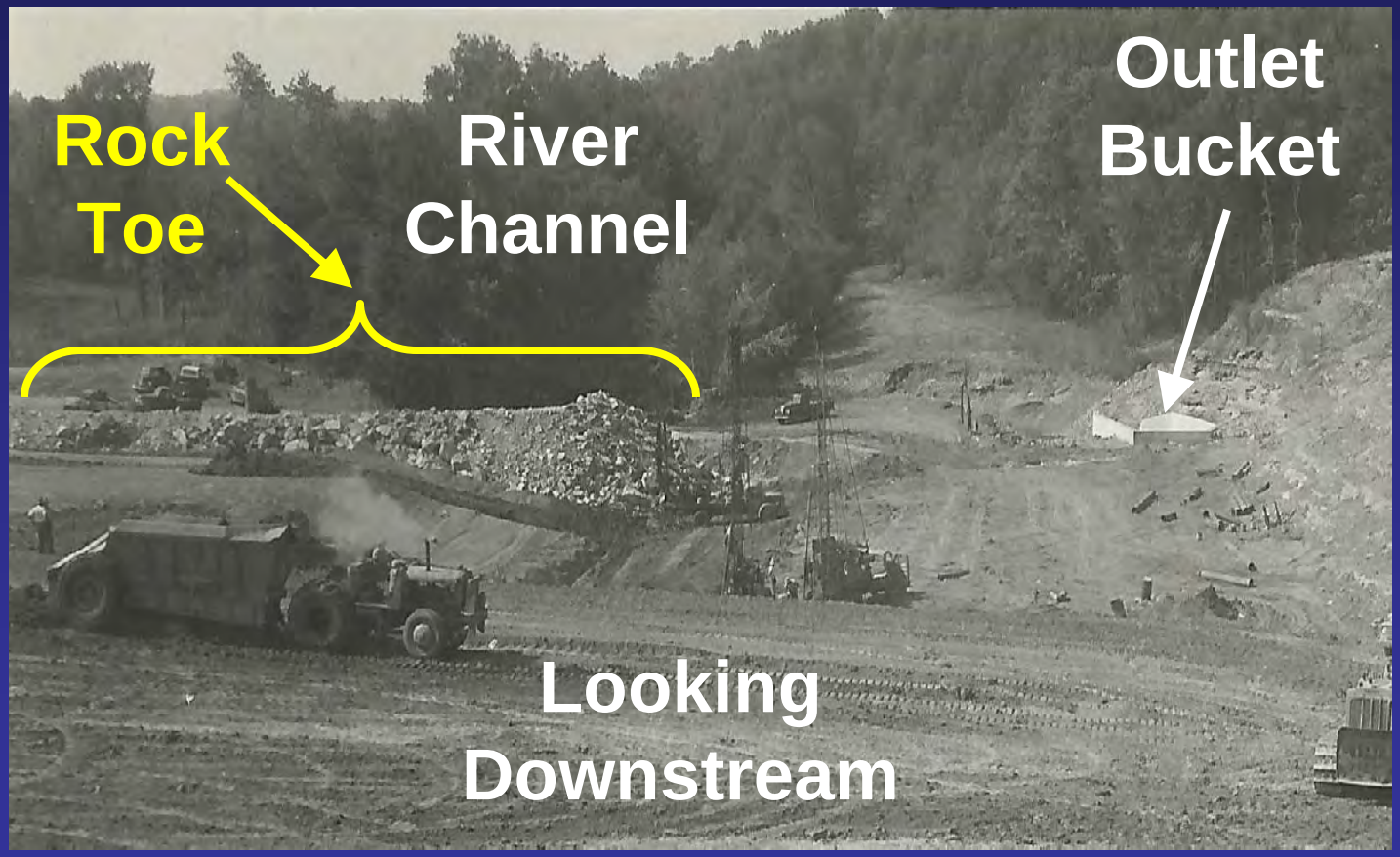
Sinkhole on Downstream Slope



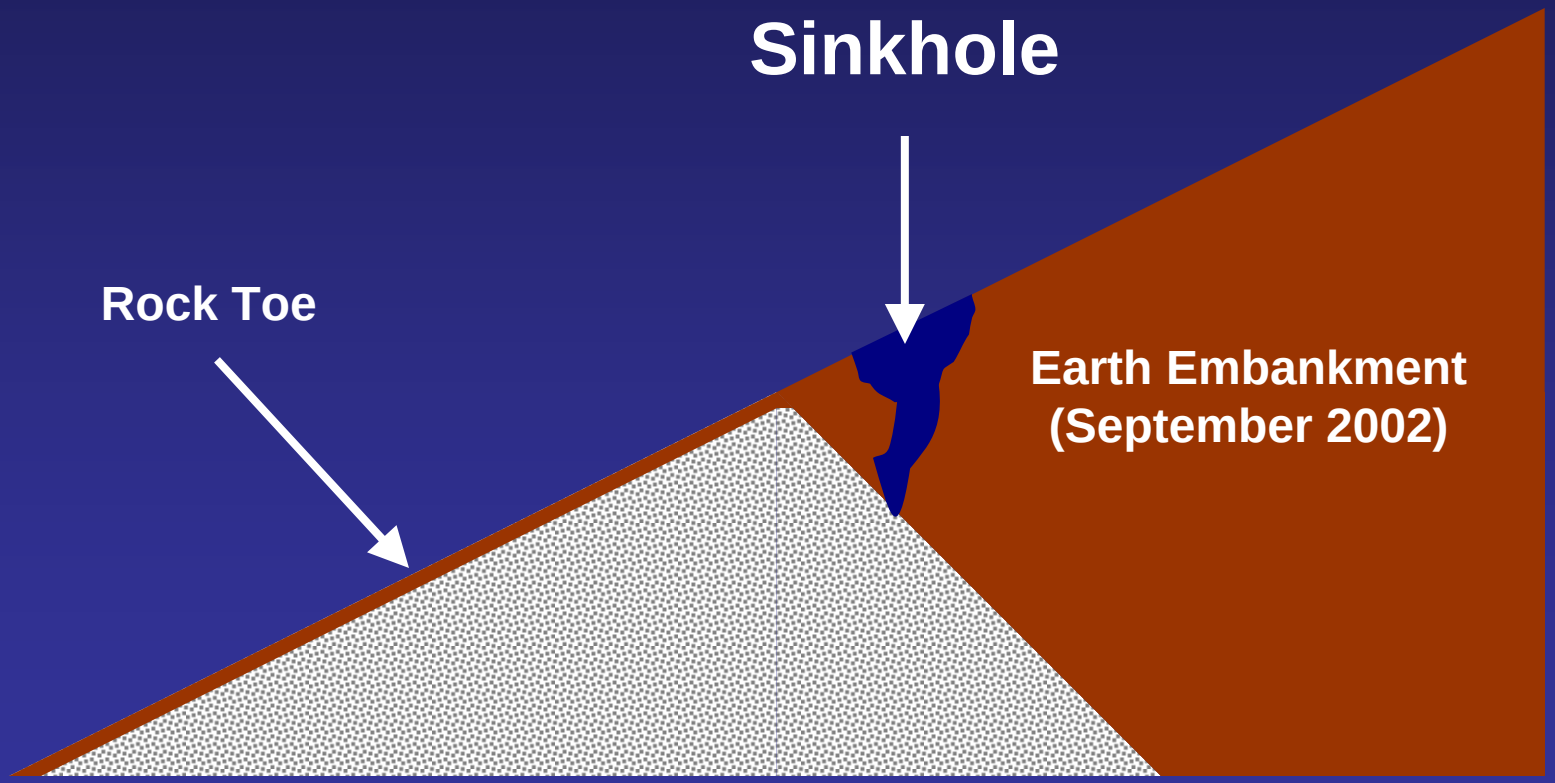
Remnants of Hurricane Isidore

- **September 2002**
- **6.5 inches of rain in 24 hours**

Rock Toe Construction



Sinkhole Development



Downstream Slope Condition

Rock Toe

Depressions

Outlet Bucket

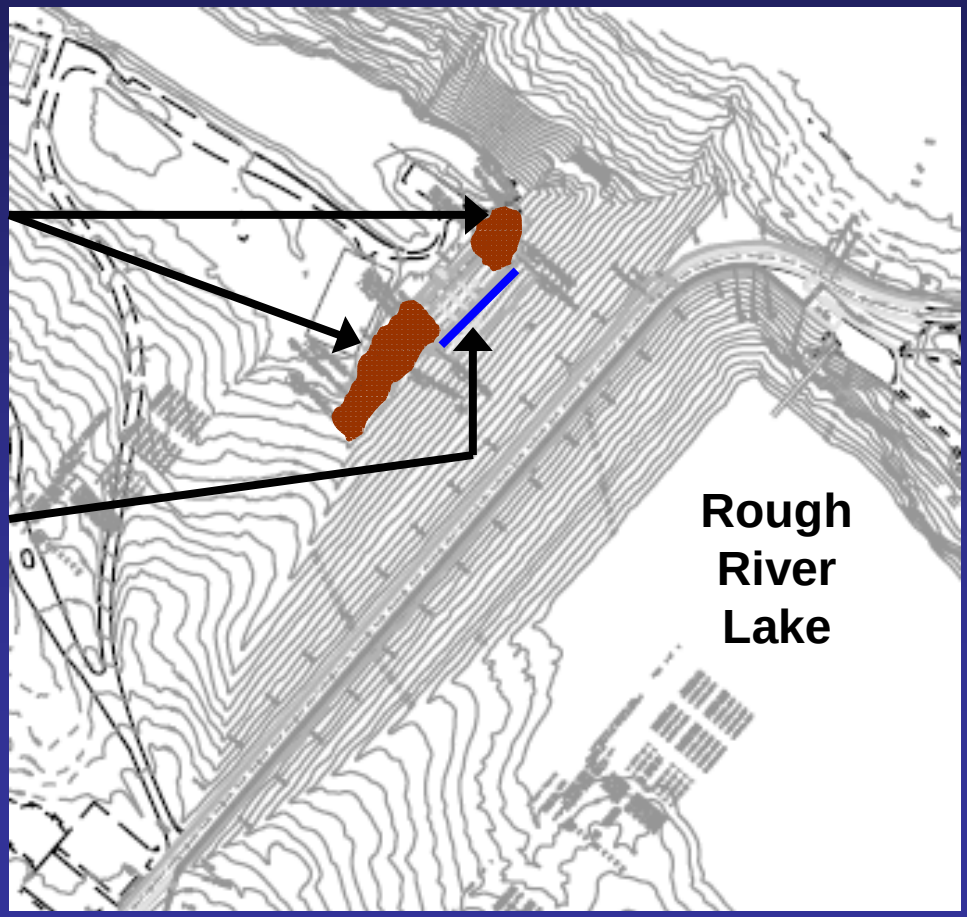
Approx. Location of Sinkhole



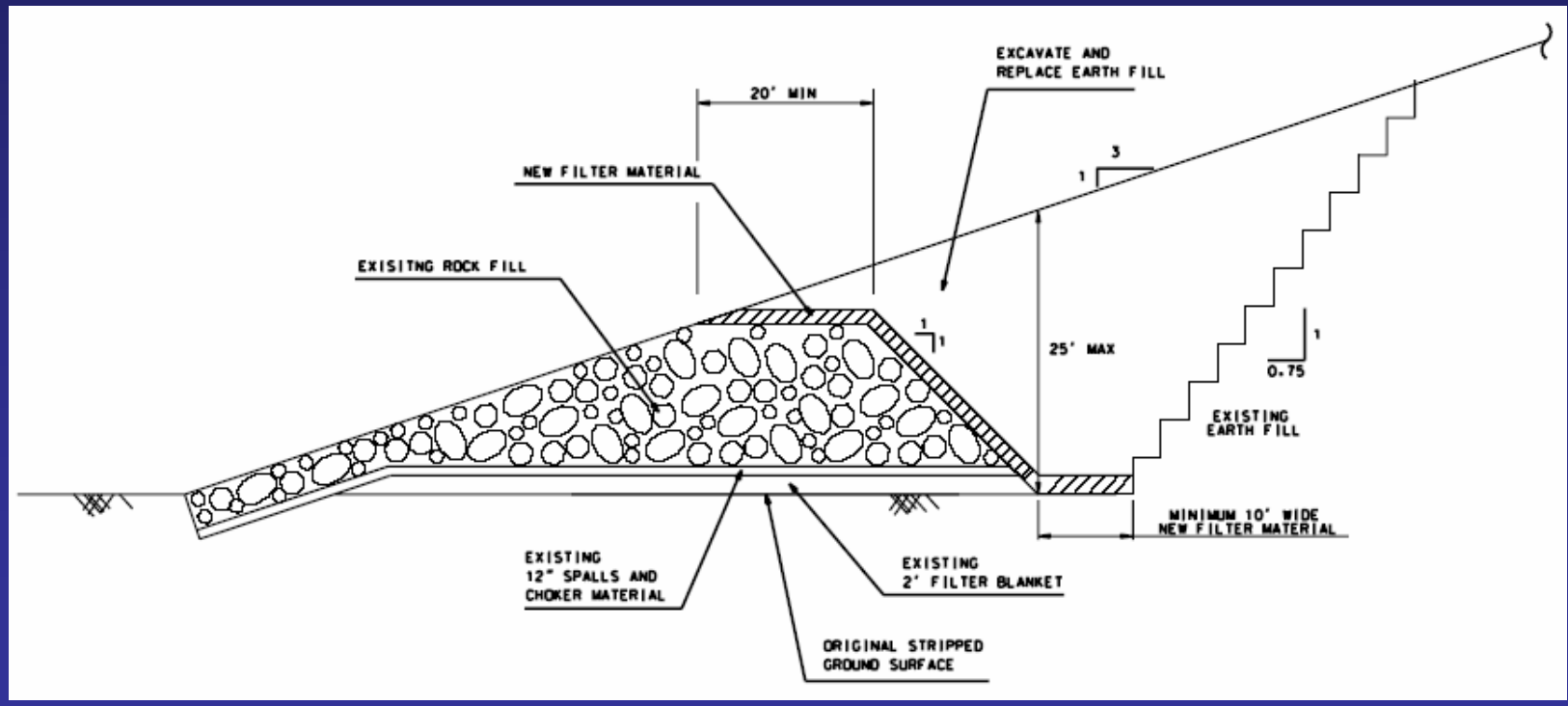
Rock Toe Repair

Complete Repair:
Excavate; place granular filter; replace earth fill

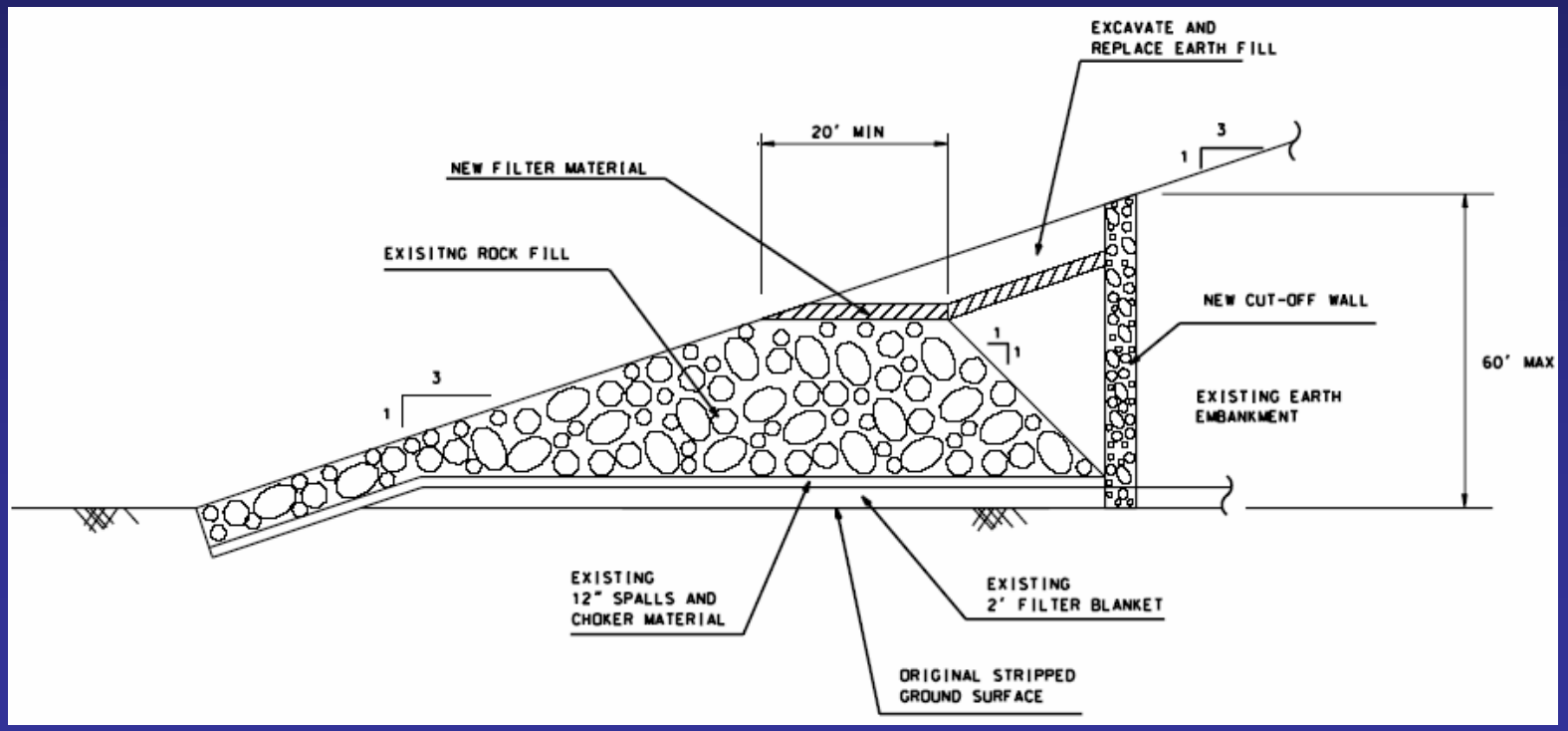
Partial Repair:
Place cutoff wall; seal surface with granular filter



Complete Rock Toe Repair: Excavate, Repair, and Replace

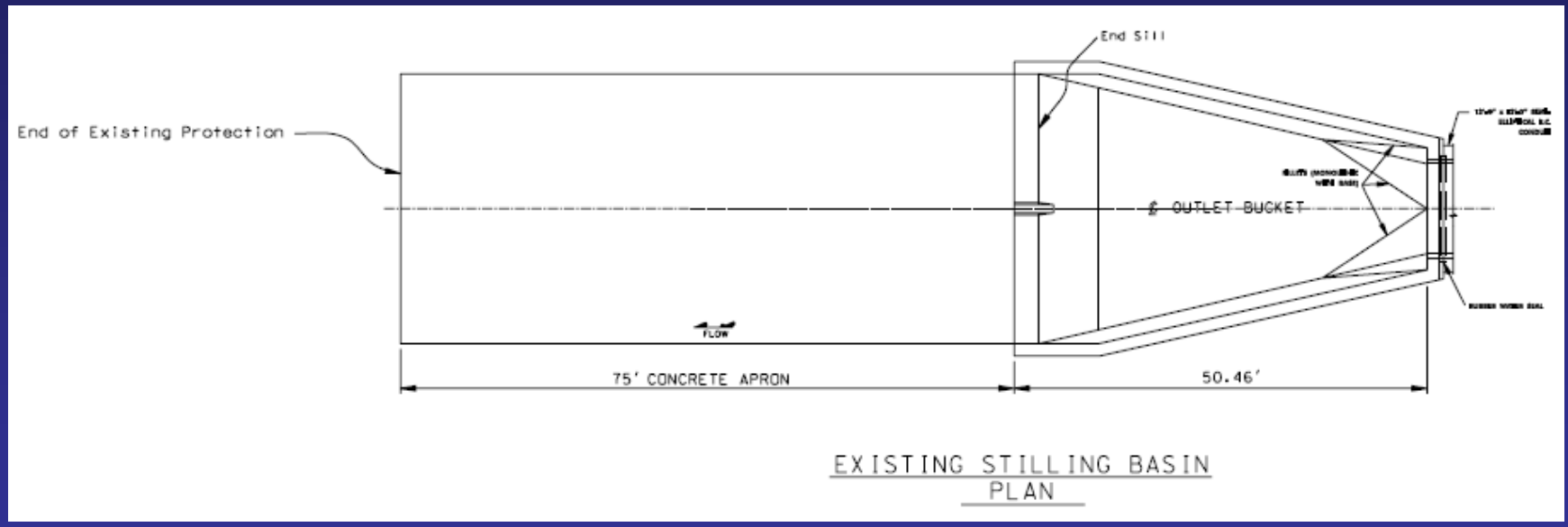


Partial Rock Toe Repair: Cutoff Wall; Seal Surface



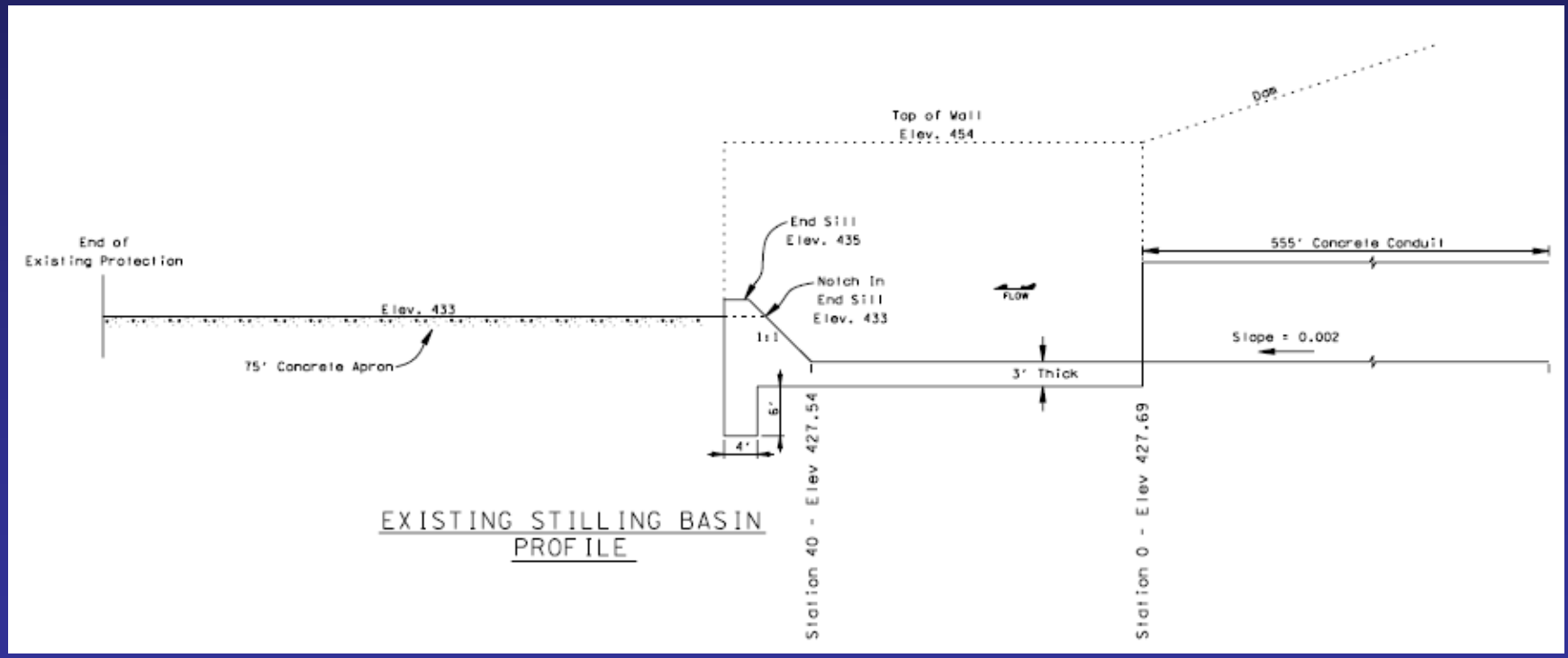
Stilling Basin Inadequacy

Plan of Existing Stilling Basin



EXISTING STILLING BASIN
PLAN

Profile of Existing Stilling Basin



Existing Stilling Basin

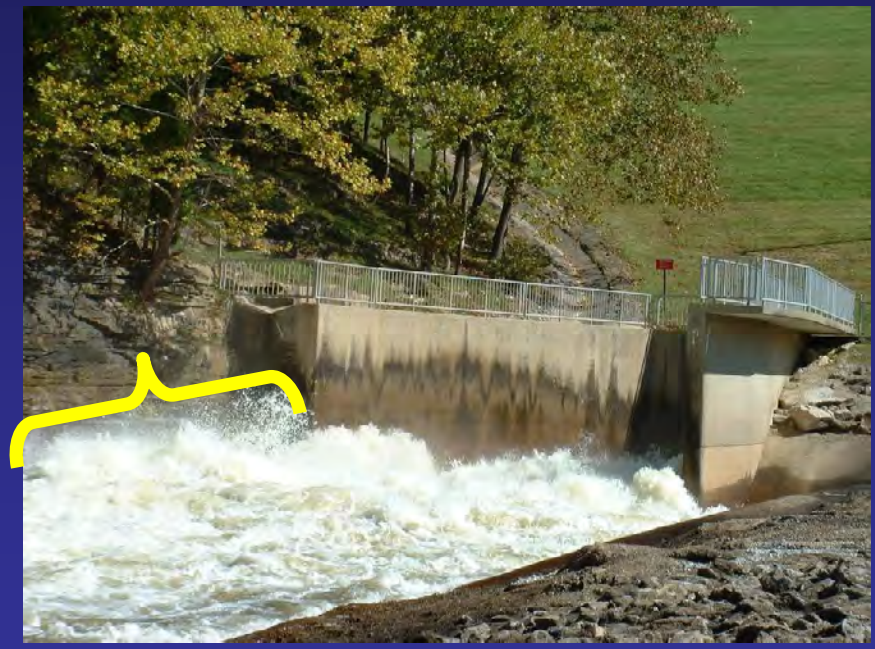




Note: Conduit nearly submerged with respect to tailwater

Existing Stilling Basin





Note: Discharge in photographs is 50% of required discharge for the design flood pool and 20% less than the maximum discharge for channel capacity.

Consequences of No Stilling Basin Modification





Stilling Basin Remediation

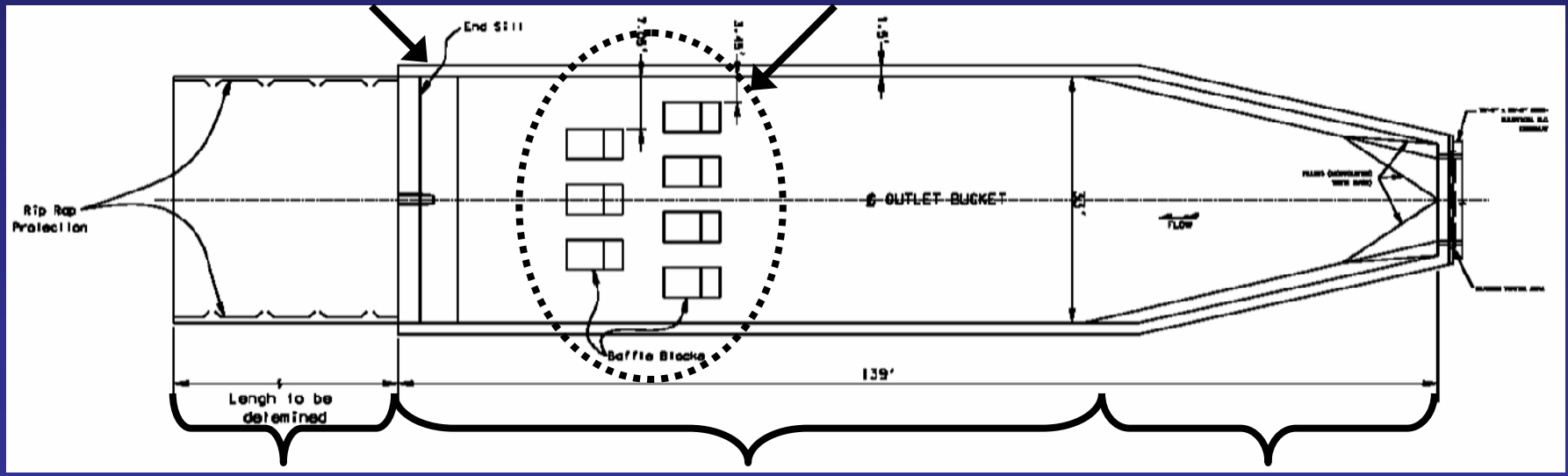
ERDC 1:25-scale model study:

- Lengthen Basin: Move end sill ±90 feet downstream and add baffle blocks
- Downstream Weir: Construct a weir downstream of the existing apron in conjunction with some channel armoring

Conceptual Modification I: Lengthened Stilling Basin Plan

End Sill

Baffle Blocks

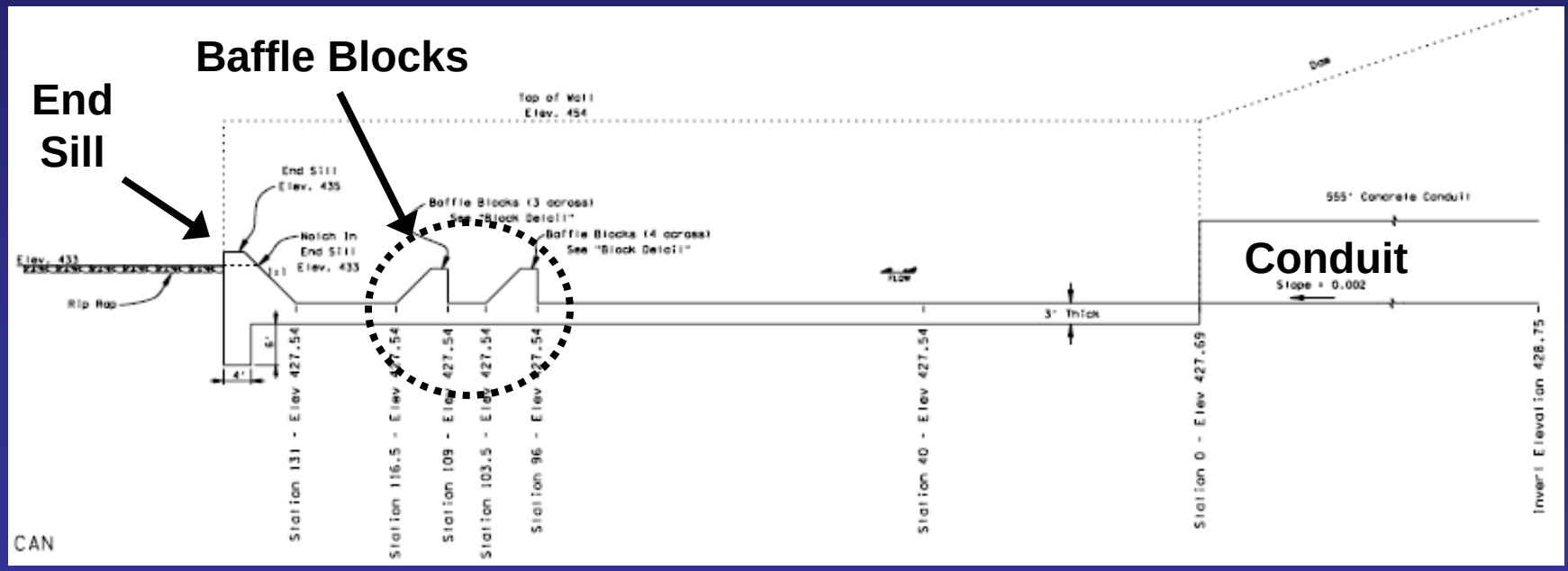


New Rip Rap

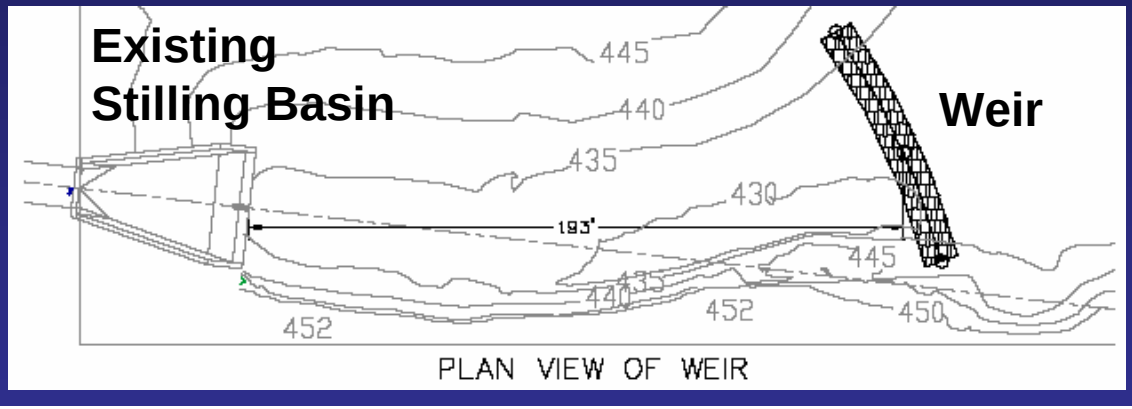
Lengthened Stilling Basin (±90 feet)

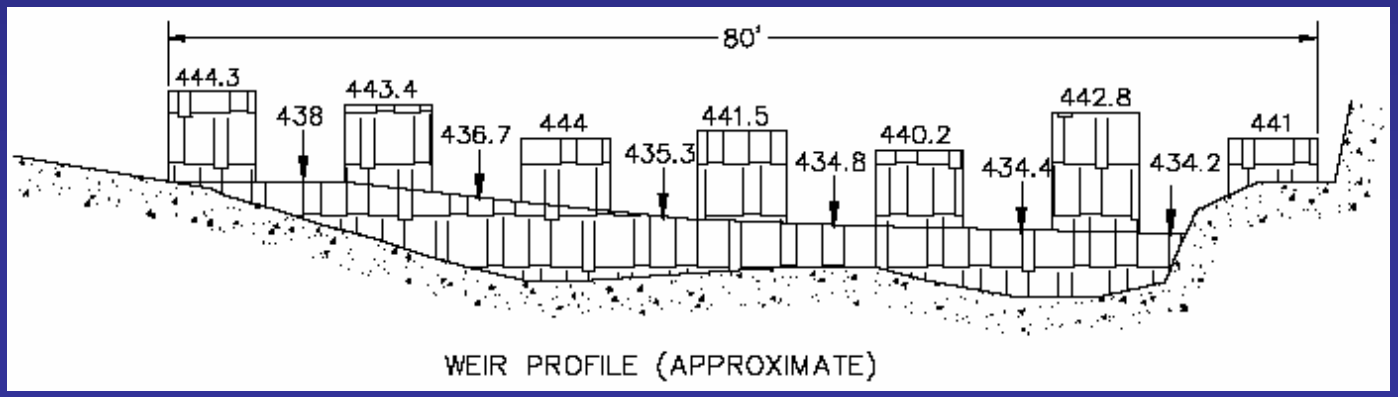
Existing Stilling Basin (±50 feet)

Conceptual Modification I: Lengthened Stilling Basin Profile



Conceptual Modification II: Construct Downstream Weir





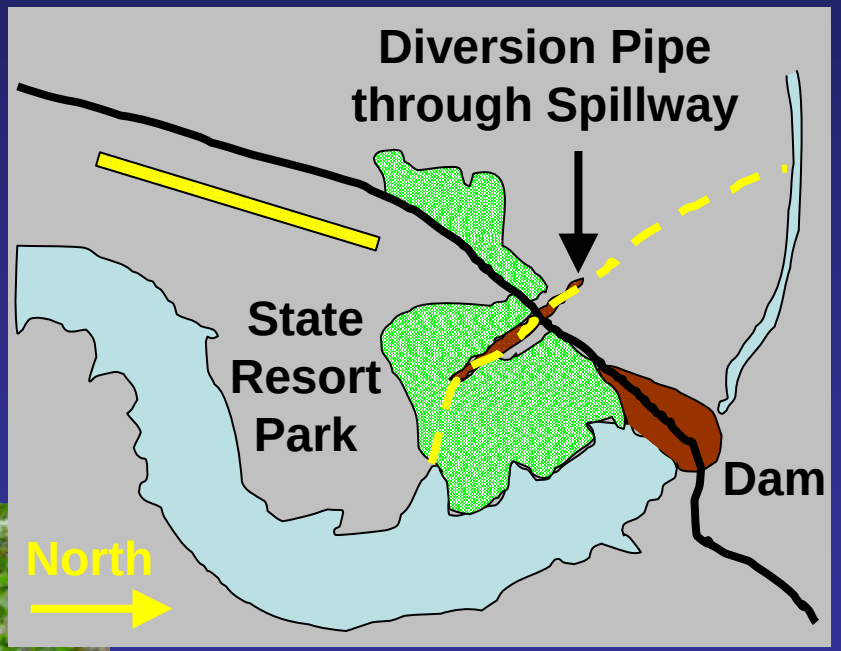
Tailwater Improvements

- Raise grade of access road at toe of dam to prevent flooding during high tailwater
- Expand parking lot; provide turn-around
- Add fishing platform along river bank
- Construct ADA-accessible fishing platform along top of new stilling basin wall

Construction Water Control

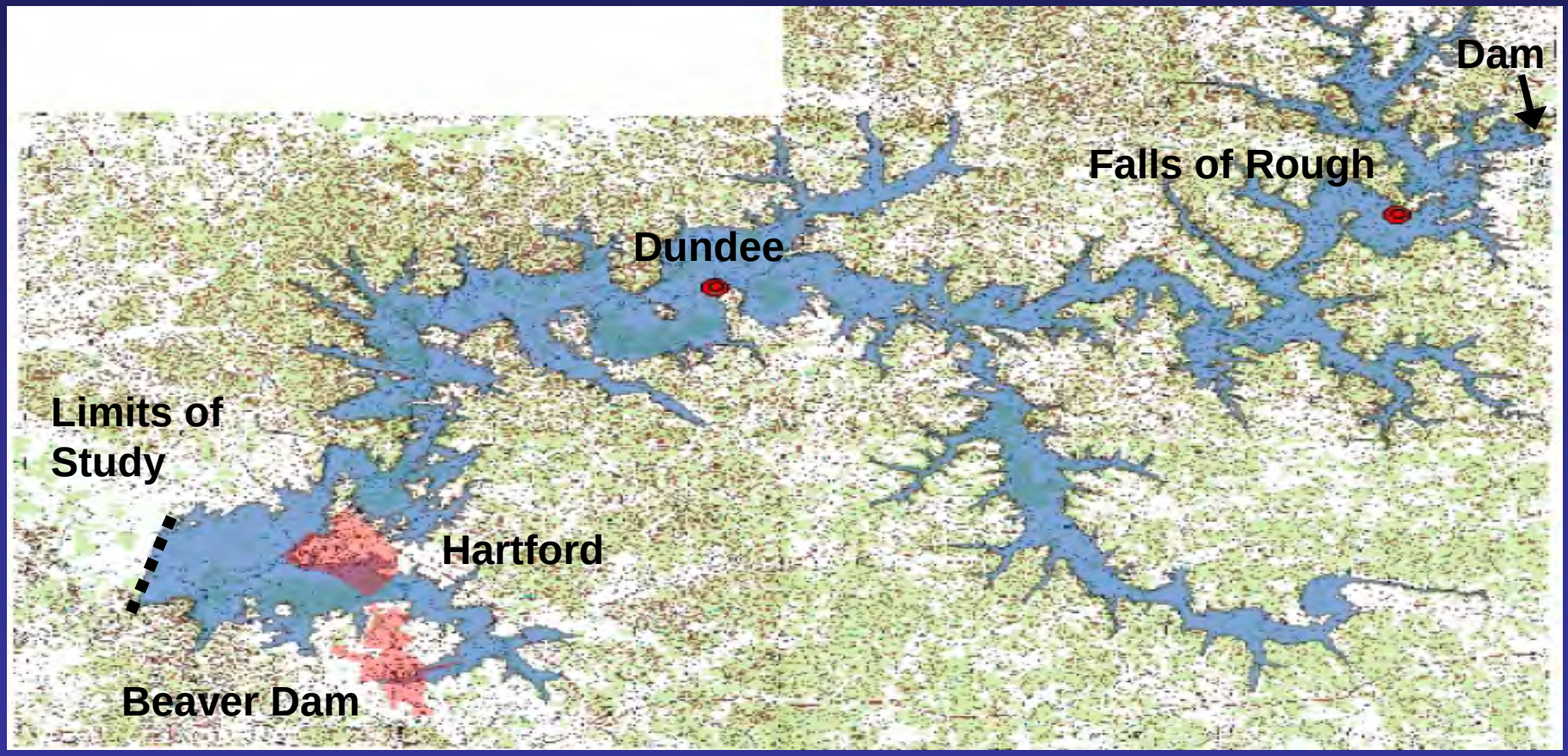






Consequences

PMF Dam Break Inundation



Economic Losses with Dam Failure

Immediate urban flood damage	$19.8M
Annual flood control benefits lost	$ 4.5M
Annual recreation benefits lost	$ 8.3M
Total annual benefits lost	$12.8M

Economic Losses with Dam Failure (cont.)

Original construction cost	$ 2.4M
Dam replacement	$20.5M
Rebuild Lafayette Golf Course	$ 2.0M

Economic Losses with Dam Failure (cont.)

- Loss of water supply:

Grayson County	25,000
Breckinridge County	19,200
Total Population	44,200

- Agricultural losses: 28,600 total crop acres
- Environmental/ecological losses

Human Consequences with Dam Failure

	Population at Risk (PAR)	Loss of Life (LOL)
Permanent	1,258	5 (1 to 11)
Transient	6,750	28 (5 to 56)
Total	8,008	33 (6 to 67)

Project Schedule

	Design Complete	Award Contract	Construction Complete
Spillway and Rock Toe Remediation:	Sep. 2005	Dec. 2005	Oct. 2006
Stilling Basin Remediation:	Mar. 2006	Aug. 2006	Mar. 2007

Project Funding

FY 2005 CG/Wedge: Model Study, Design	$0.5M
FY 2006 CG: Construction, S&A, EDC	$2.2M
FY 2007 CG: Construction, S&A, EDC	$2.0M
Total	$4.7M

Conclusions

"Our emphasis continues to be public safety and to minimize public inconvenience."

- Common Sense
- Courtesy
- Communication, communication, communication

Contact Information

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Louisville, Kentucky 40201-0059
Attn: CELRL-ED-T-G

(502) 315-6599 / (502) 315-6454 (Fax)
timothy.m.oleary@LRL02.usace.army.mil

Questions?



Slope Stability Evaluation of the Baldhill Dam Right Abutment

Presentation for the

2005 Tri-Service Infrastructure Systems Conference



by

Neil T. Schwanz

RTS Geotechnical Engineer

4 August 2005

Motivation

History of Right Abutment Displacement

Continued Movements

Expanded Record of Instrumentation

Establish Slope Stability Models

- ✓ **Recent Conditions**
- ✓ **Predict Future Loading Conditions**

Acknowledgments

MVP Geologists and Instrumentation Group

Omaha District and Local Testing Labs

MWH (formerly Harza Engineering)

University of Minnesota

Topics

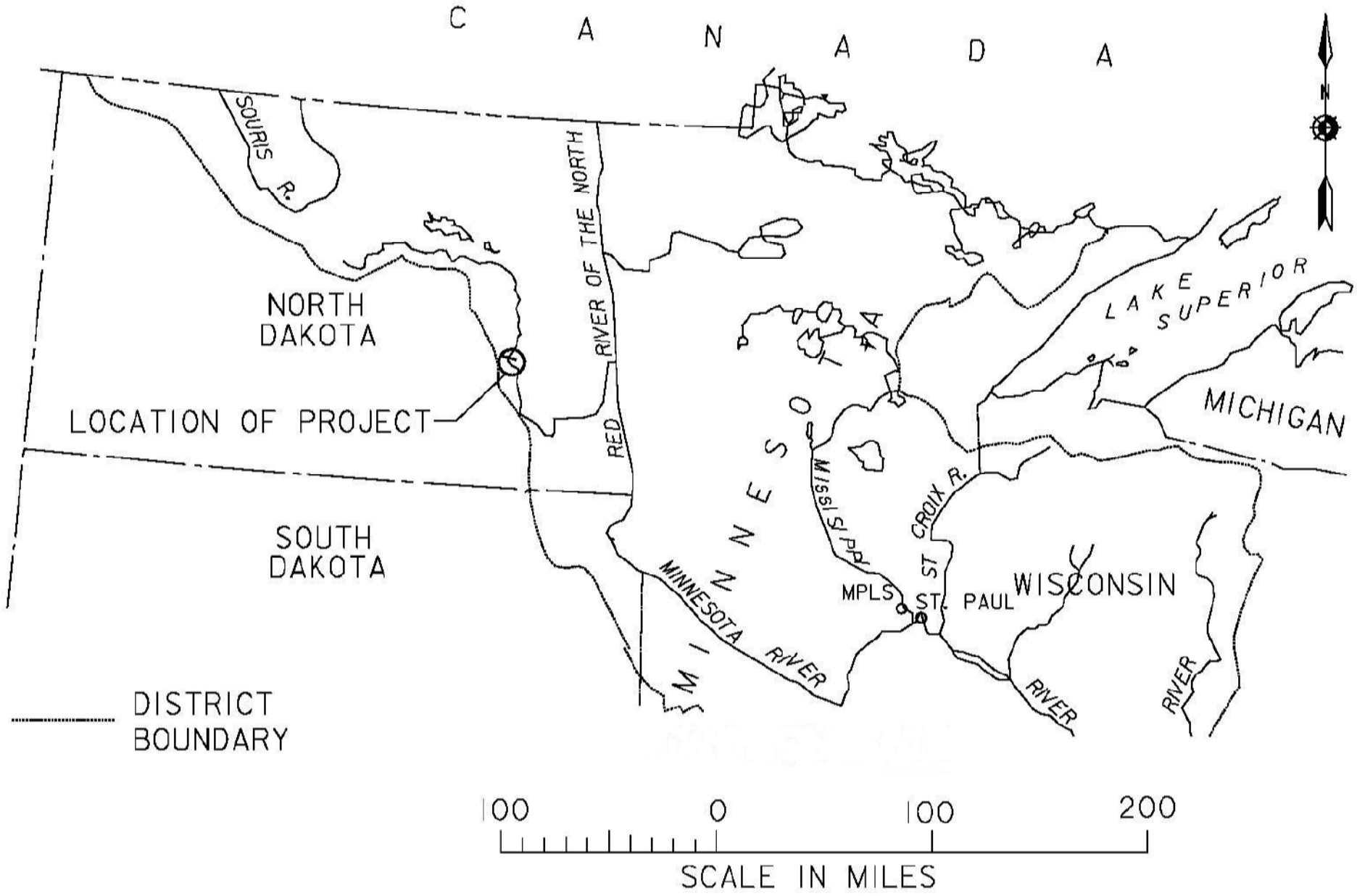
Project Background

Pressuremeter Testing

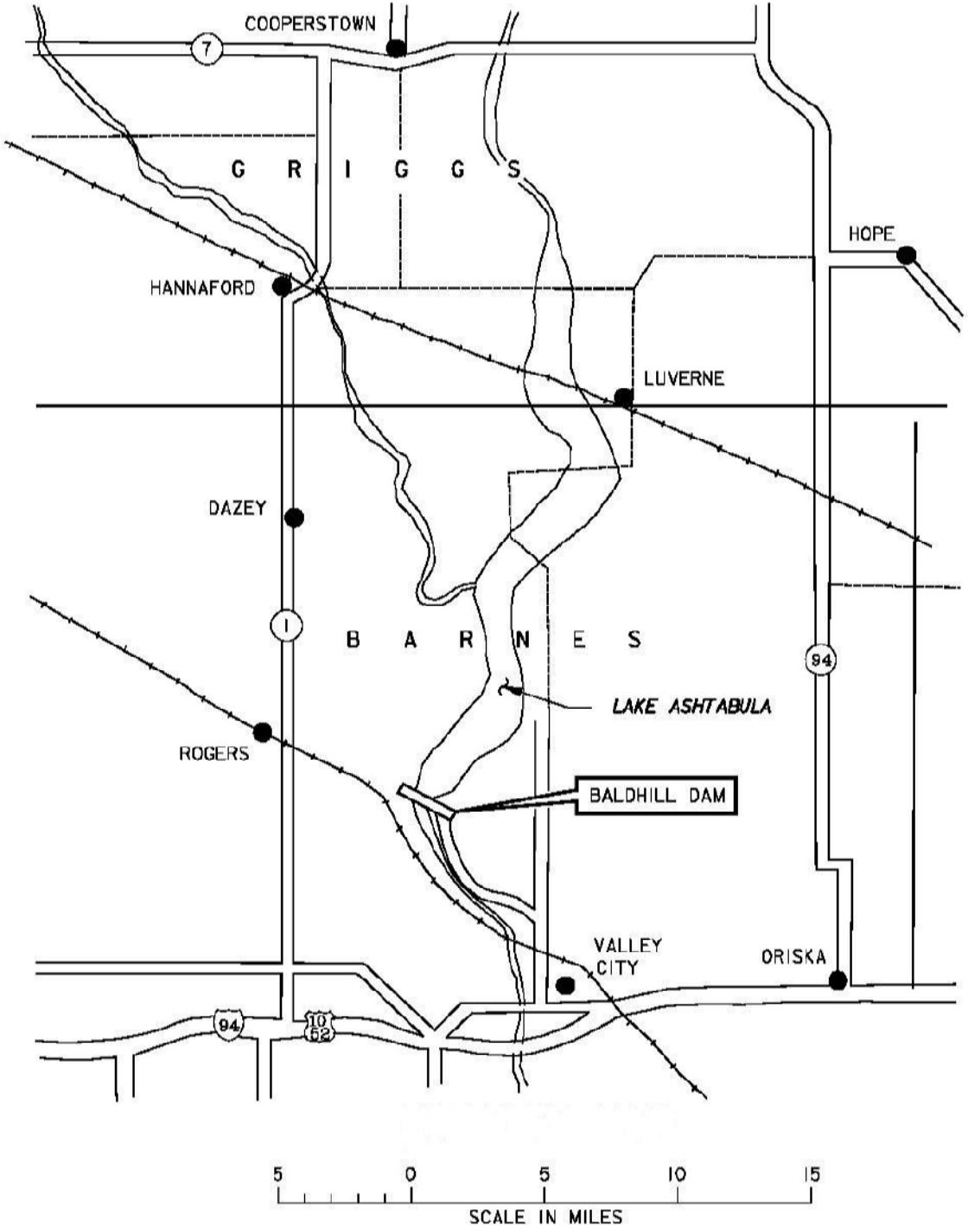
Laboratory Testing Data Interpretation

Slope Stability Analyses

- ✓ **Limit Equilibrium**
- ✓ **Numerical**


C A N A D A
SOURIS R.
RIVER OF THE NORTH
RED
NORTH DAKOTA
LOCATION OF PROJECT
SOUTH DAKOTA
MINNESOTA
MISSISSIPPI
ST CROIX R.
MINNESOTA RIVER
MPLS
ST. PAUL
WISCONSIN
LAKE SUPERIOR
MICHIGAN
RIVER
RIVER
DISTRICT BOUNDARY
100 0 100 200
SCALE IN MILES

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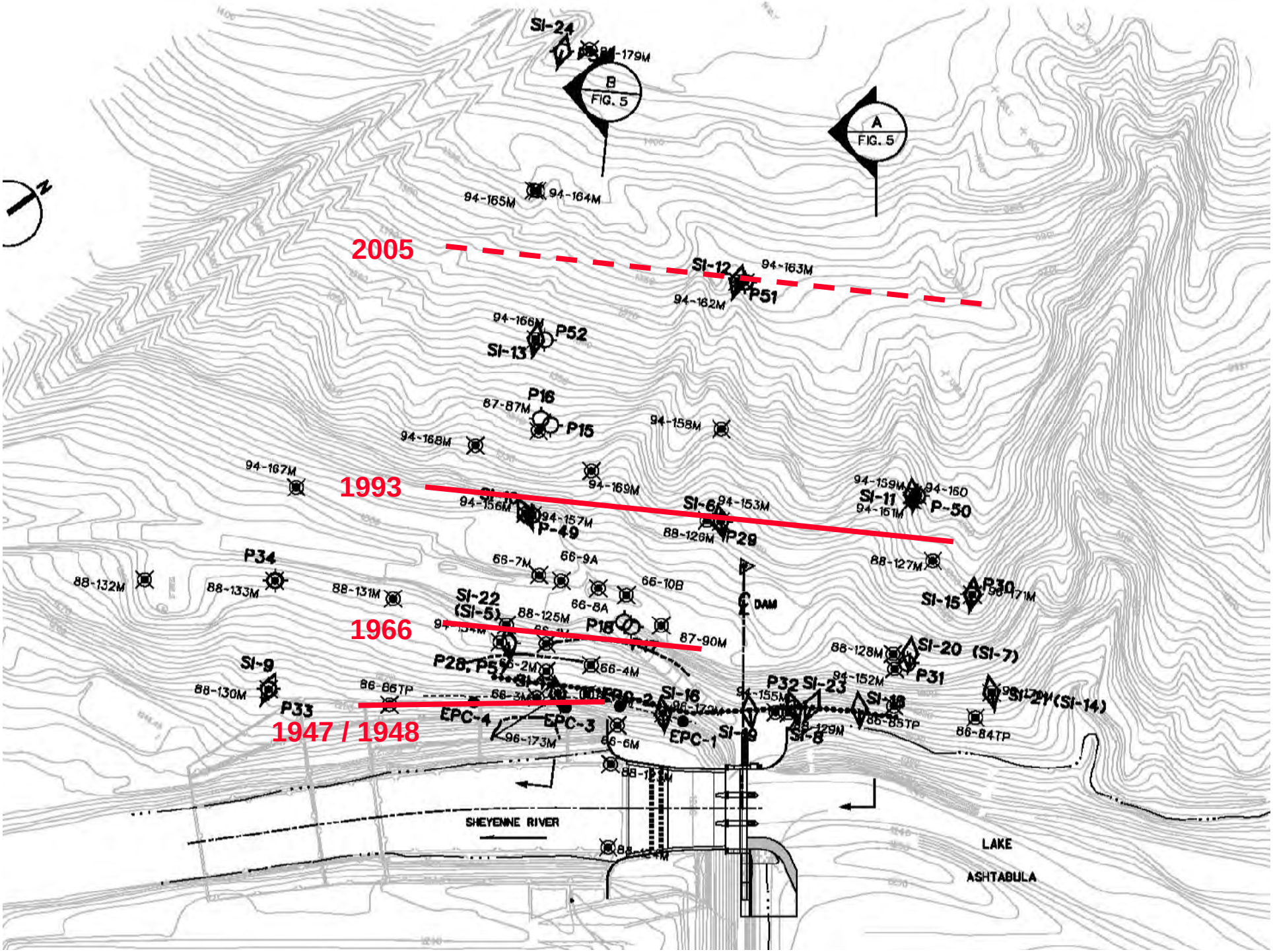


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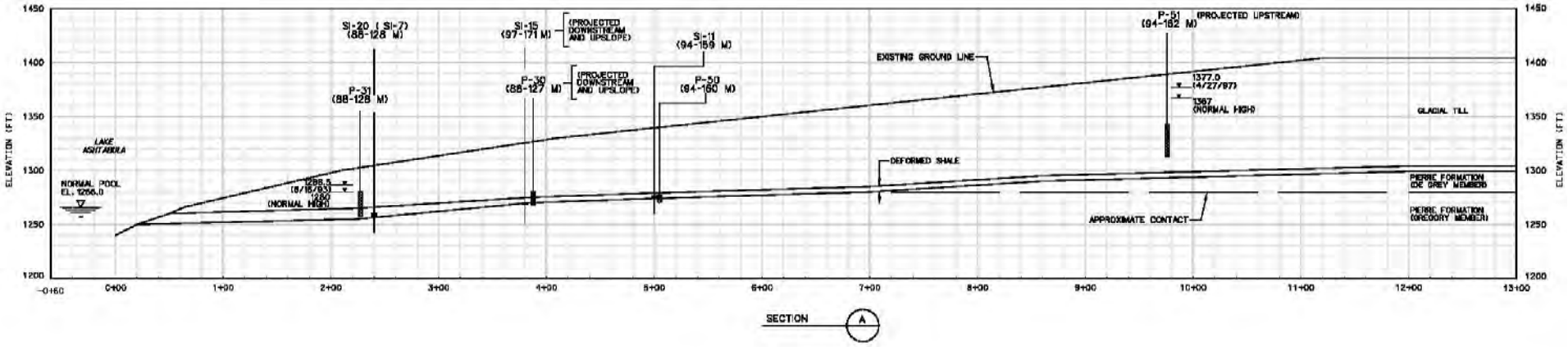
Main Features

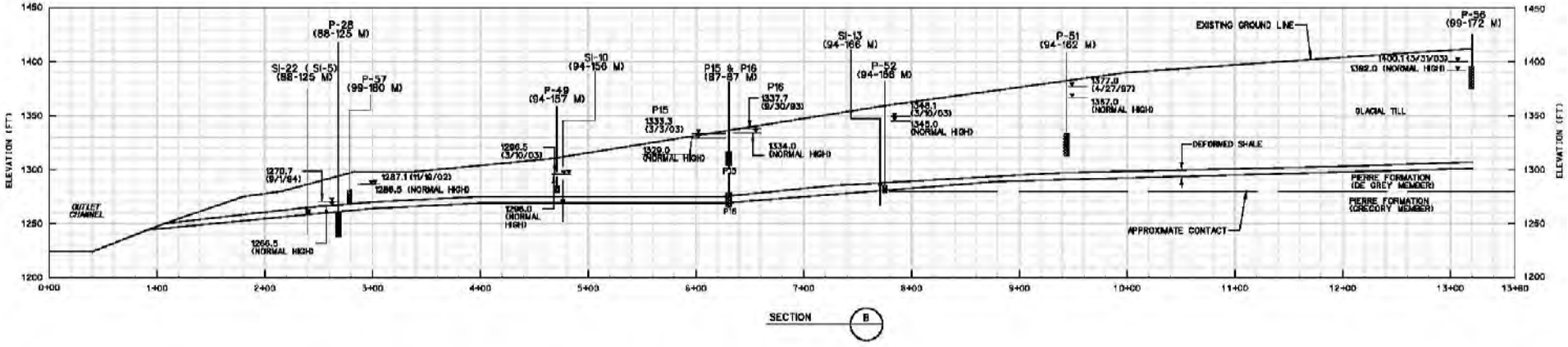



Right Abutment Area
of Concern


2005
1993
1966
1947 / 1948
SI-24
B
FIG. 5
A
FIG. 5
94-165M
94-164M
SI-12
94-163M
P51
94-162M
94-166M
P52
SI-13
P16
87-87M
P15
94-168M
94-158M
94-167M
94-169M
94-156M
94-157M
P-49
SI-6
94-153M
88-126M
P29
94-159M
94-160
SI-11
94-161M
P-50
88-127M
P34
88-132M
88-133M
88-131M
66-7M
66-9A
66-10B
66-8A
SI-22
(SI-5)
88-125M
P18
87-90M
DAM
SI-15
P30
88-128M
SI-20 (SI-7)
P31
94-152M
SI-9
88-130M
P33
86-86TP
P28, P57
66-2M
66-4M
EPC-4
EPC-3
96-173M
66-6M
SI-16
EPC-2
EPC-1
P32
SI-23
SI-18
86-85TP
SI-21 (SI-14)
86-84TP
SHEYENNE RIVER
LAKE
ASHTABULA

Stratigraphy



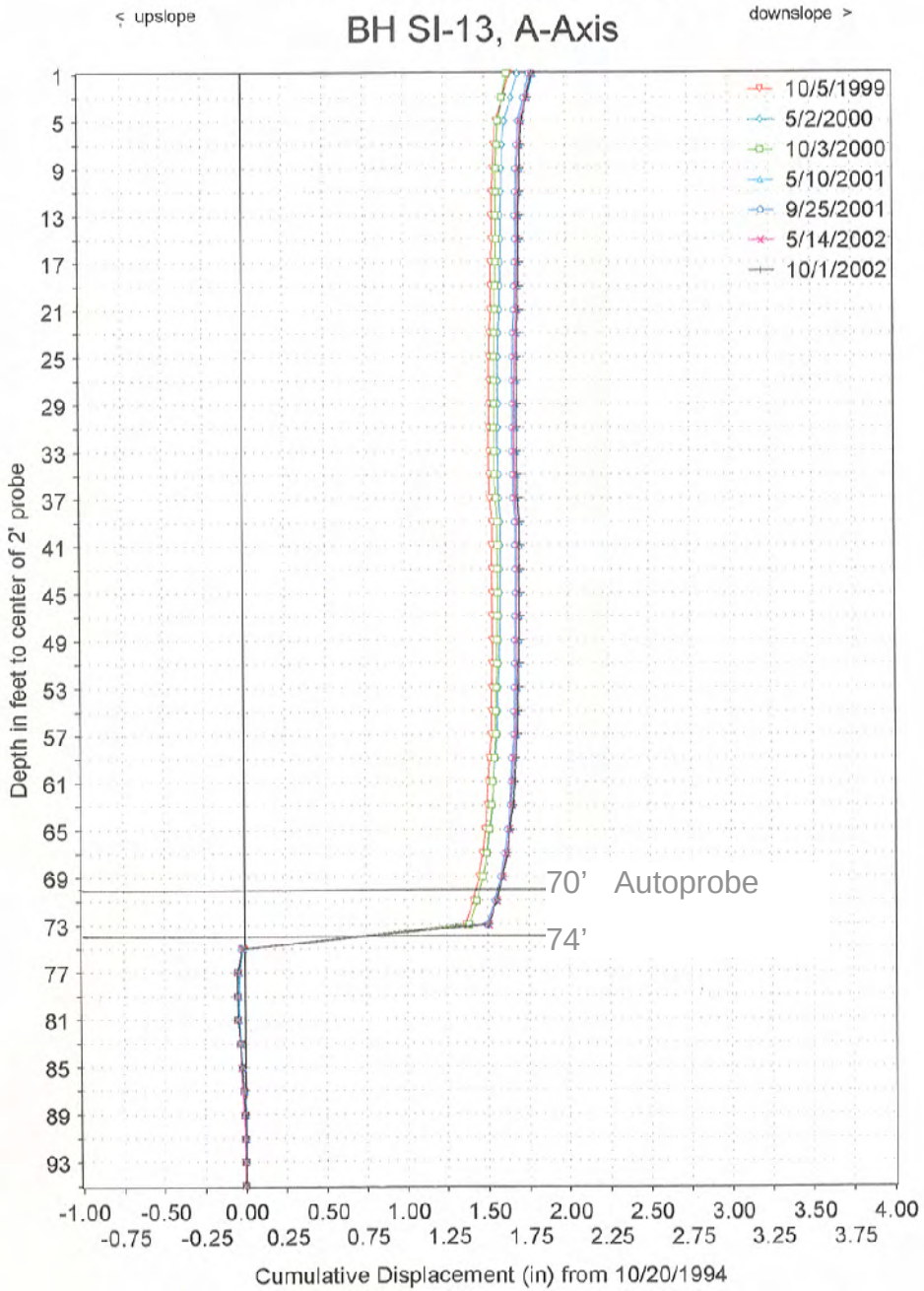


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BALDHILL DAM, LAKE ASHTABULA

INCLINOMETER DATA

BH SI-13, A-Axis



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Inclinometer Displacement

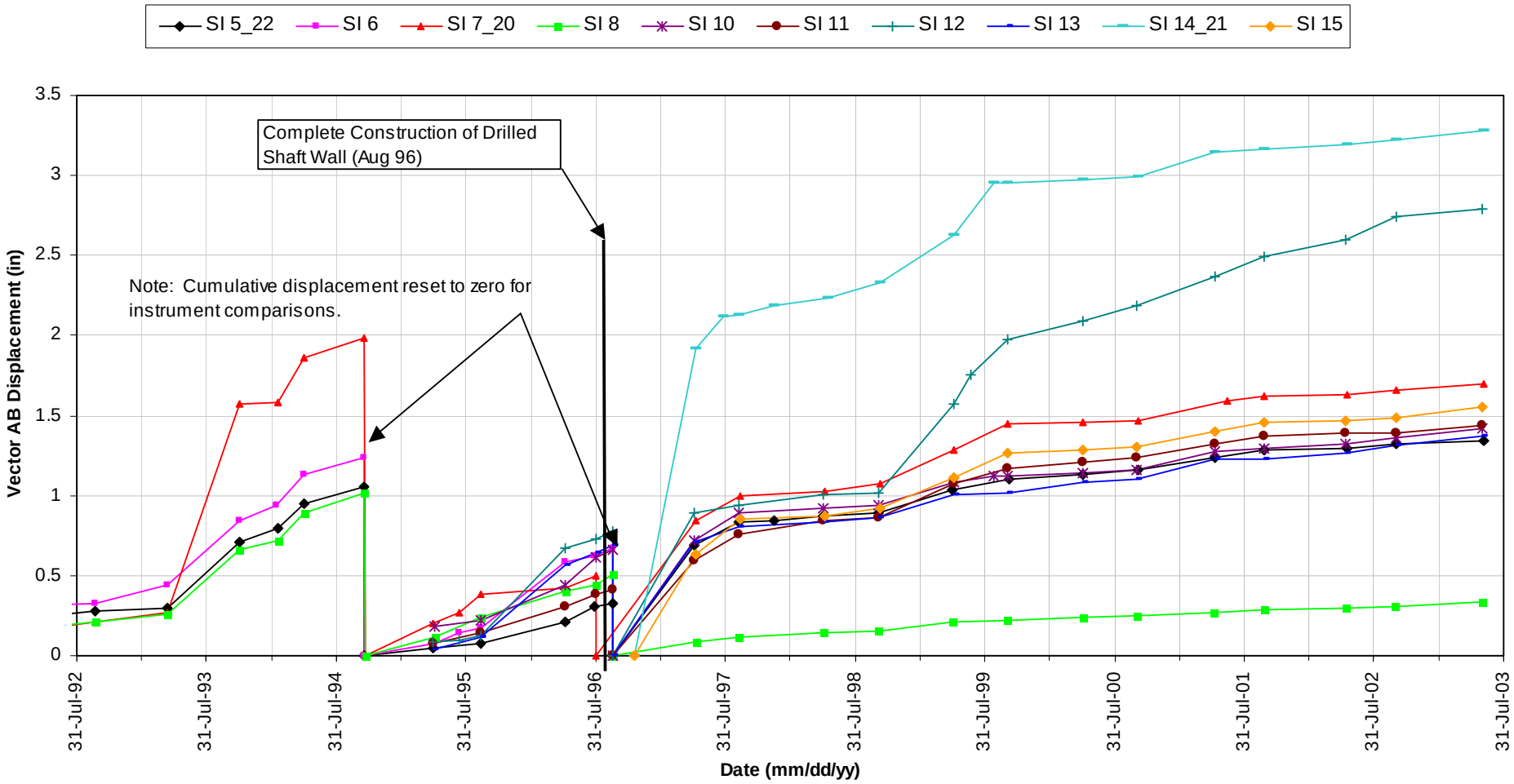
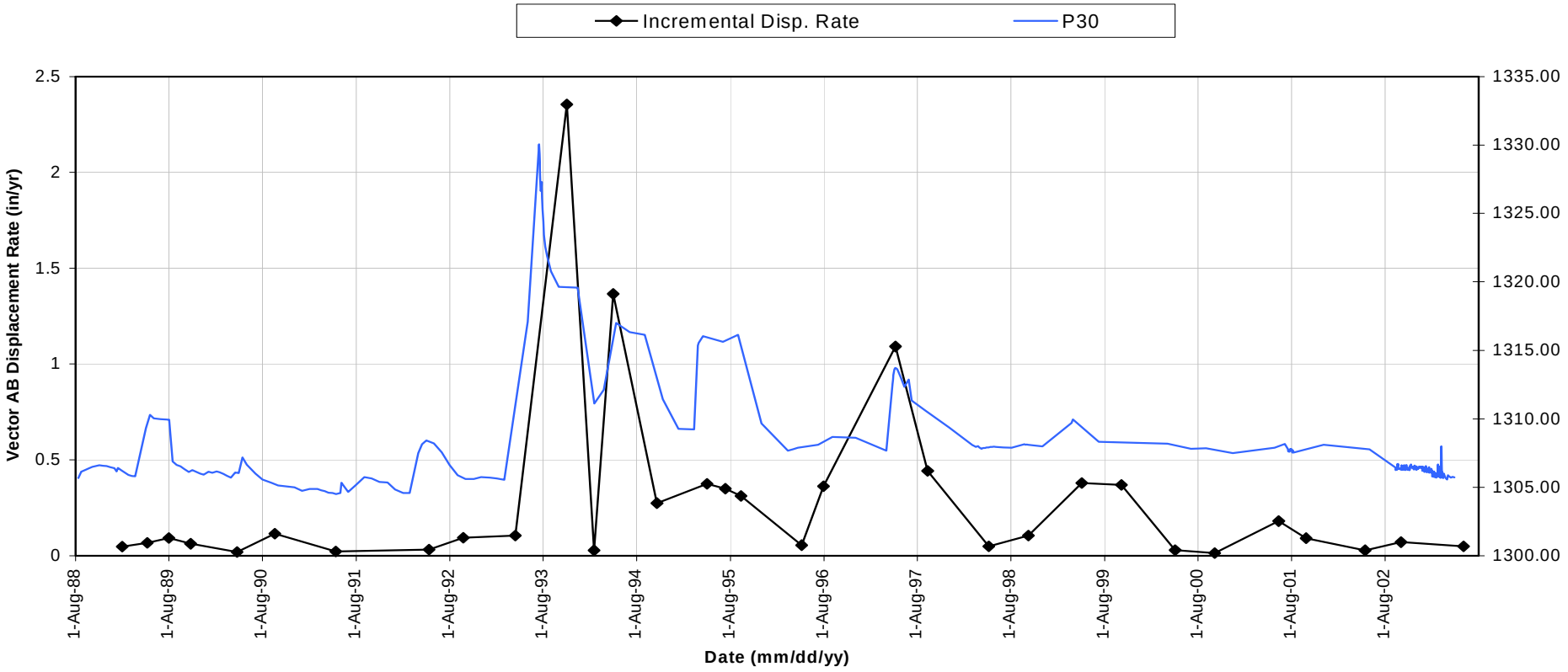


Fig. 2.8. Inclinometer Displacement Rate Comparison

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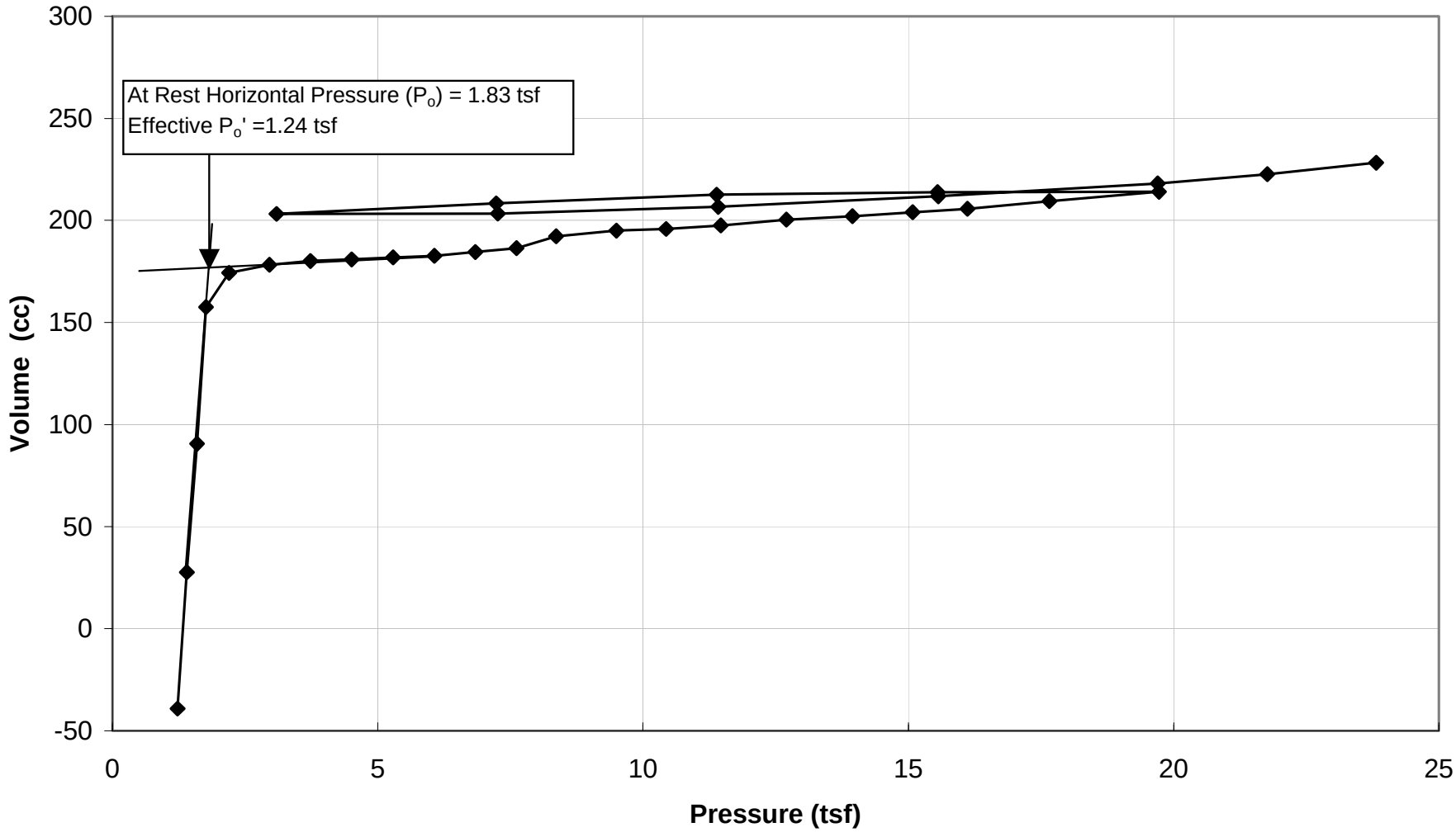
Displacement vs Pore Water Cond.



SI-7 and SI-20 (43' depth)

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Mississippi River Commission

Pressuremeter Data (D.Shale)



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Mississippi River Commission

Shear Modulus (D.Shale)

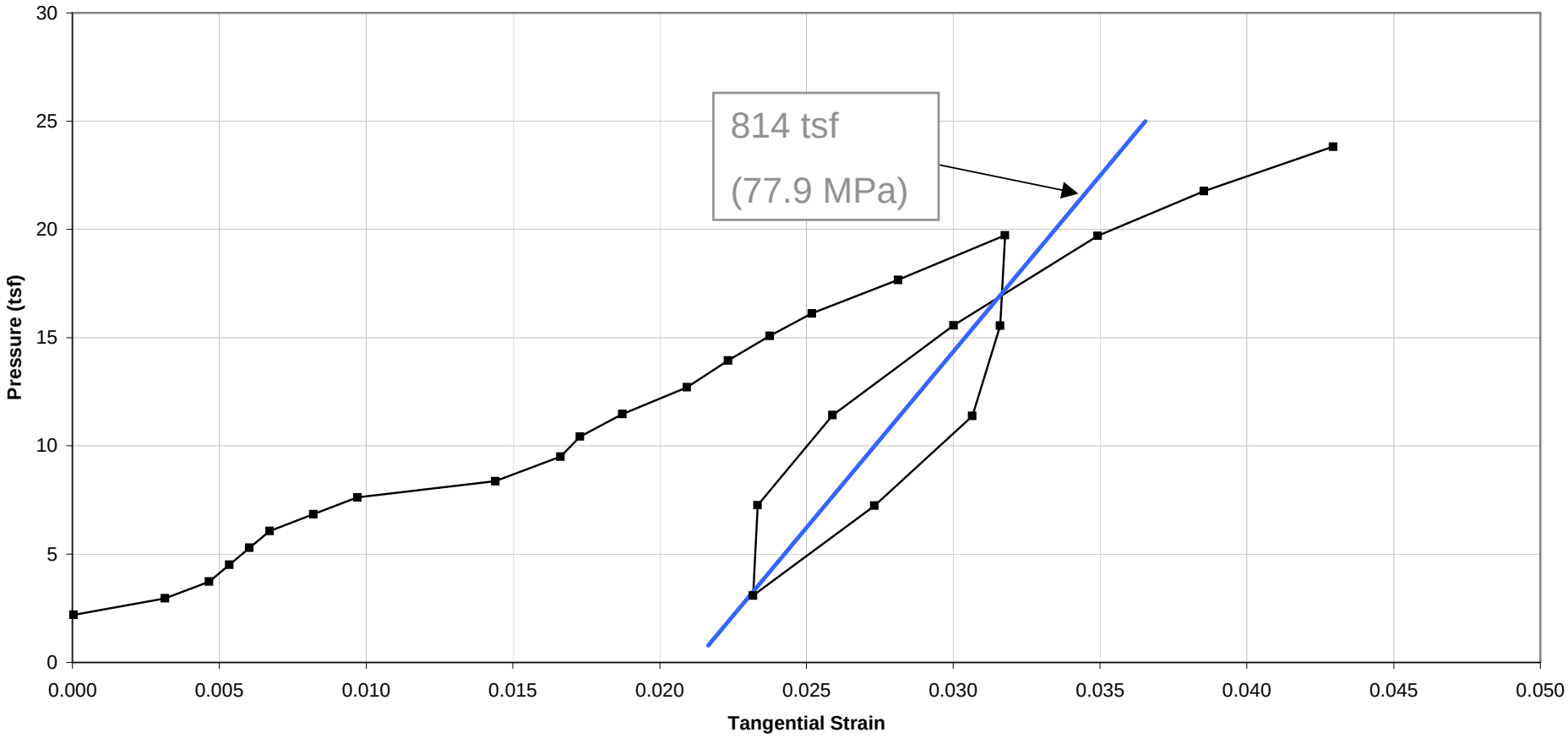


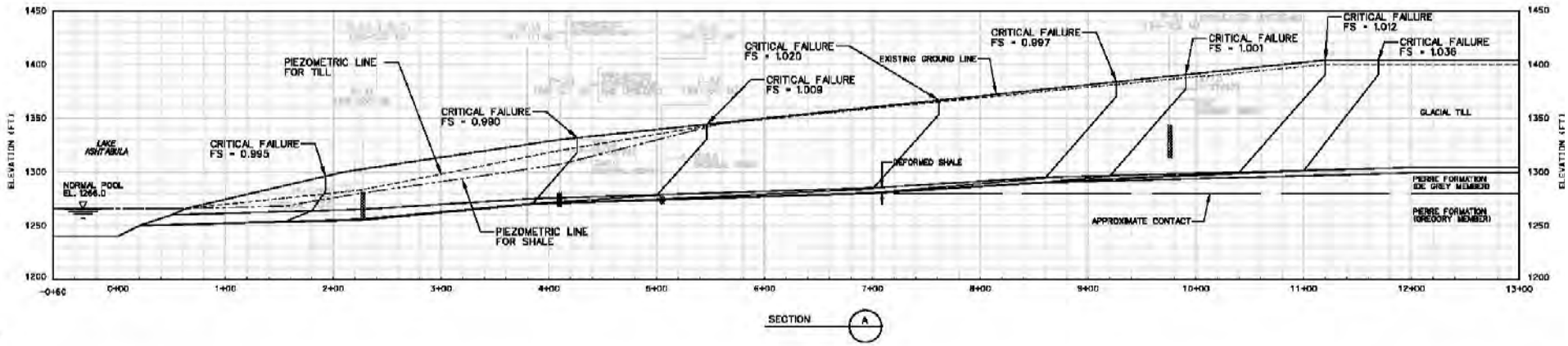
Figure D-4b. Pressuremeter Results (Deformed Shale)
Boring 02-156PM, 34.0 feet

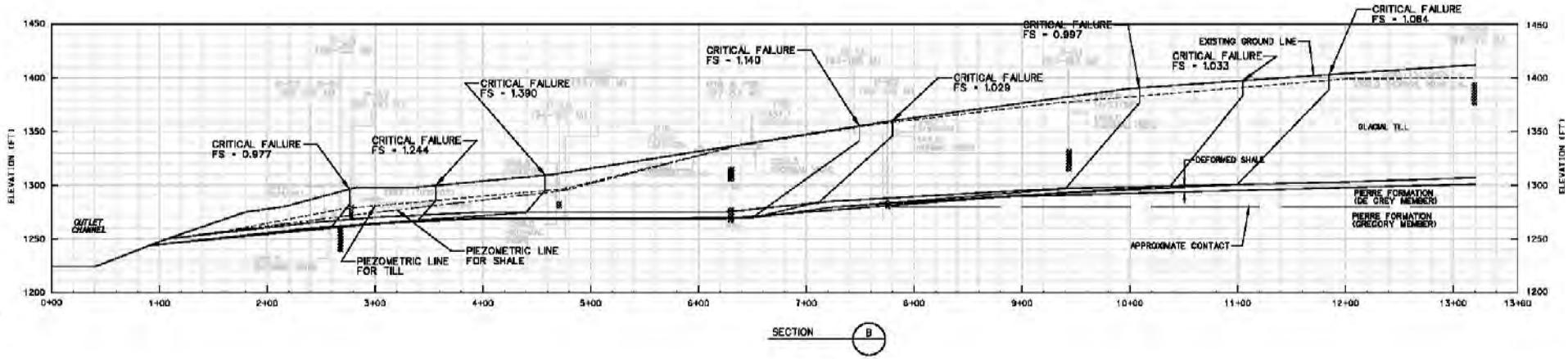
Laboratory Testing

- **Unconfined Compression**
- **Triaxial Shear Strength**
  - ✓ **Unconsolidated-Undrained**
  - ✓ **Consolidated-Undrained w/PP**
- **Direct Shear**
- **Residual Direct Shear**

Effective Shear Strength Parameters

Material	Peak				15% Strain/0.2 or 0.5 in. Displacement				Residual
	Triaxial		Direct Shear		Triaxial		Direct Shear		
	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	ϕ'_{res} (deg)
Till	500 [23.9]	25	650 [31.2]	24	600 [28.7]	23	350 [16.8]	23	16
D. Shale	1100 [52.7]	26	325 [15.6]	29	850 [40.7]	23	250 [12.0]	21	9.5
I. Shale	1975 [94.6]	35	575 [27.5]	23	375 [18.0]	23	0	16	6.3



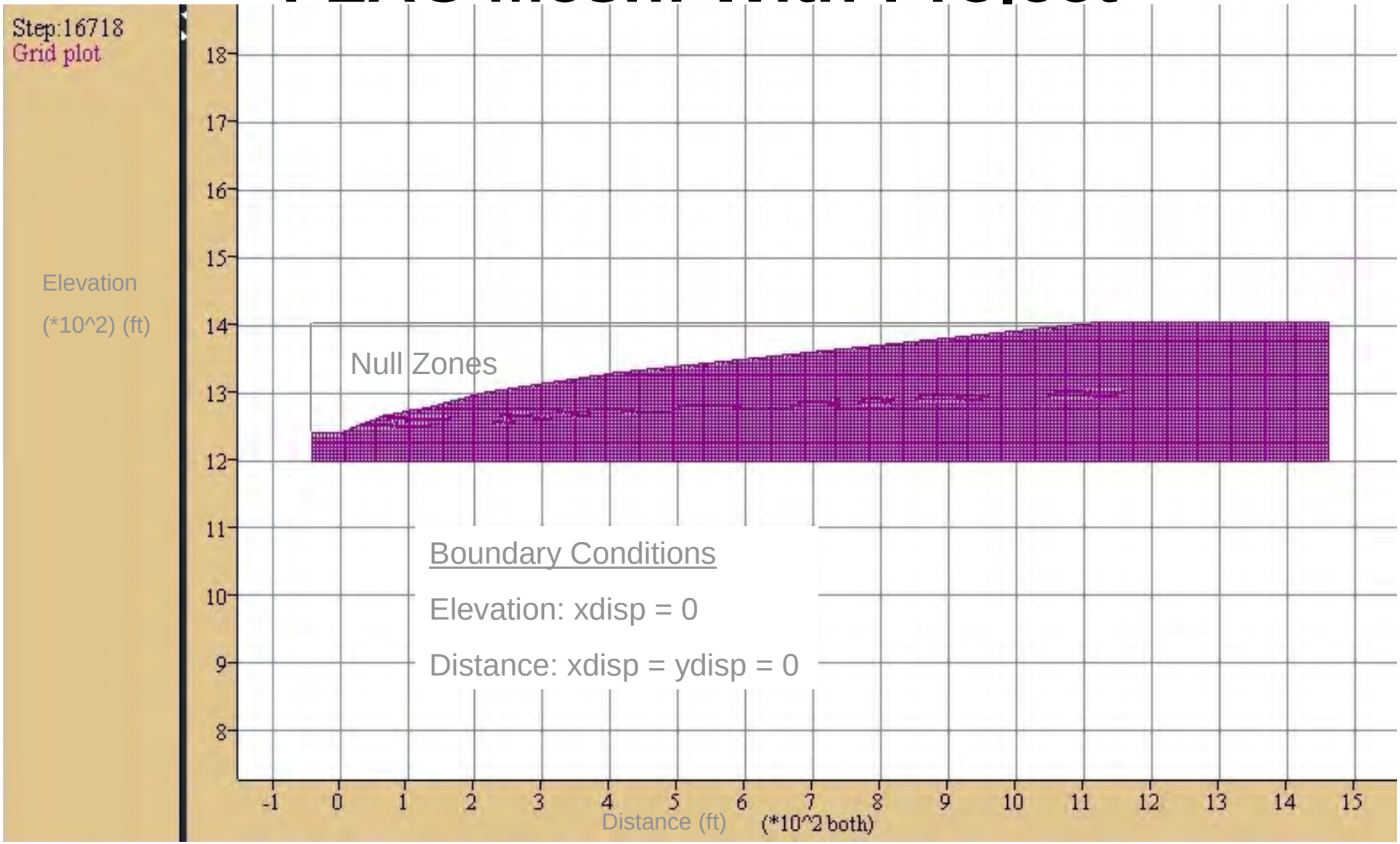


MATERIAL PARAMETERS

MATERIAL	SAT. UNIT WT. (PCF)	EFF. COHESION (PSF)	EFF. FRICTION ANGLE (DEG)
TILL	123	650	24
DEFORMED SHALE - SECTION A	125	0	9.2
DEFORMED SHALE - SECTION B	125	0	9.9
INTACT SHALE	128	600	24

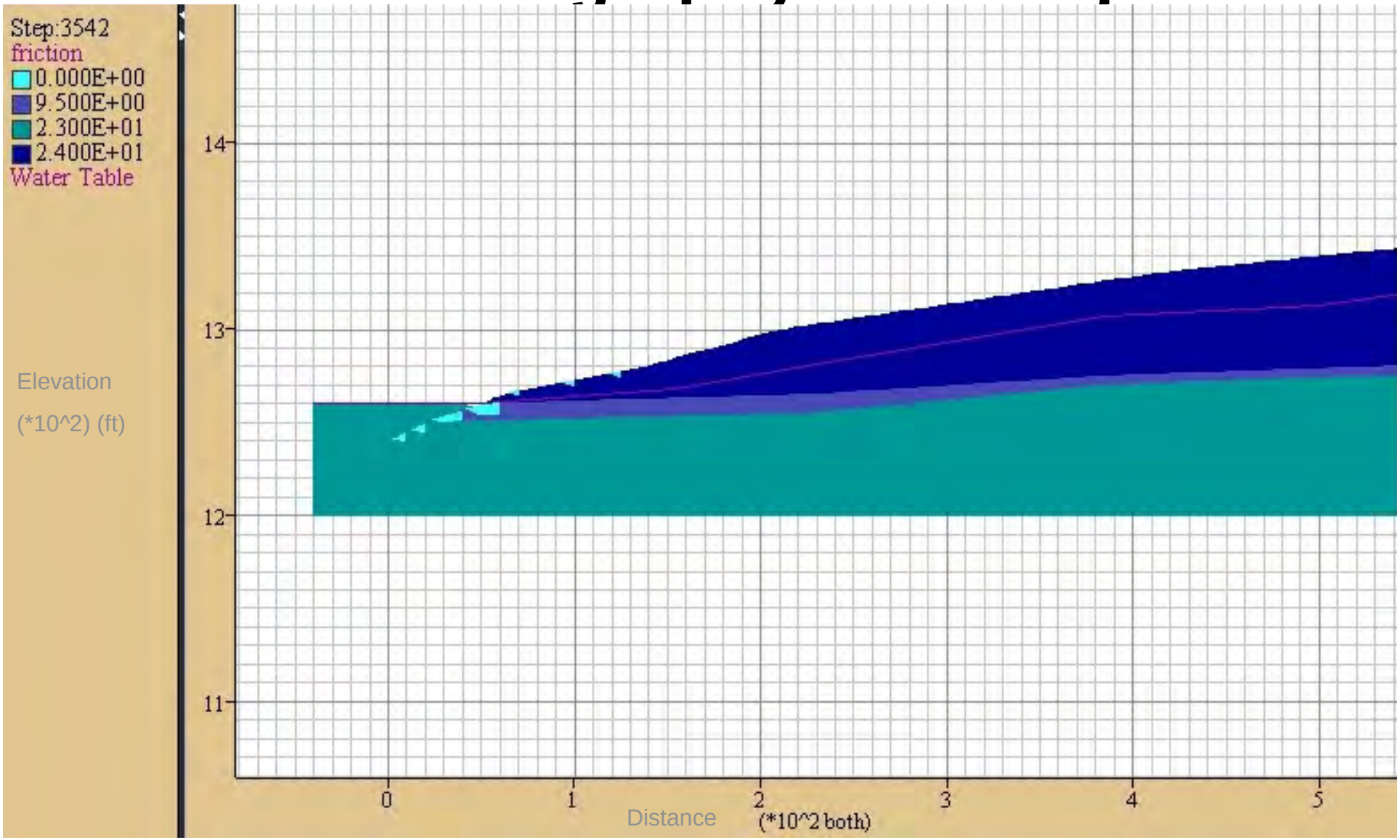
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Mississippi River Commission

FLAC Mesh: With-Project



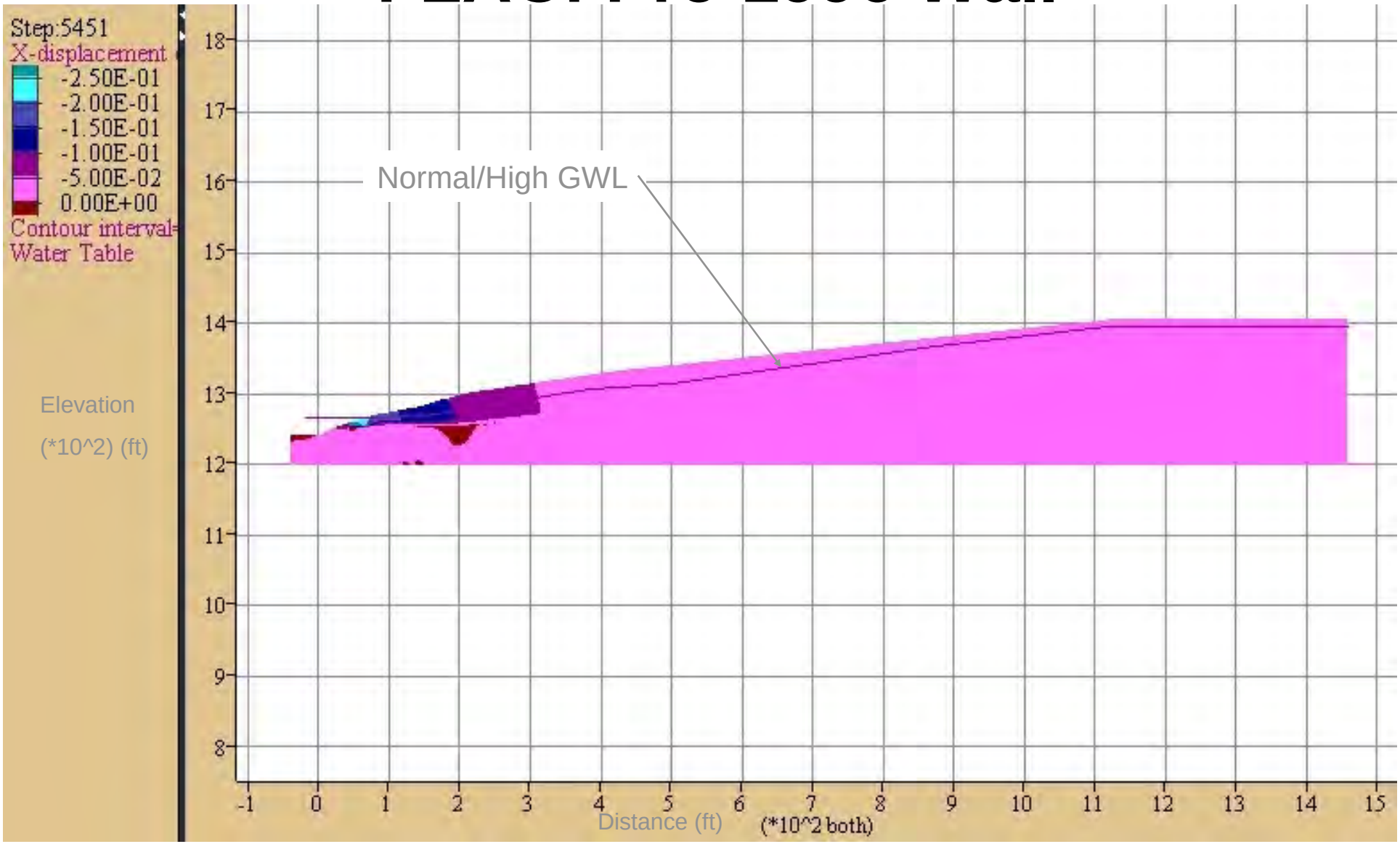
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FLAC Stratigraphy: Pre-Project



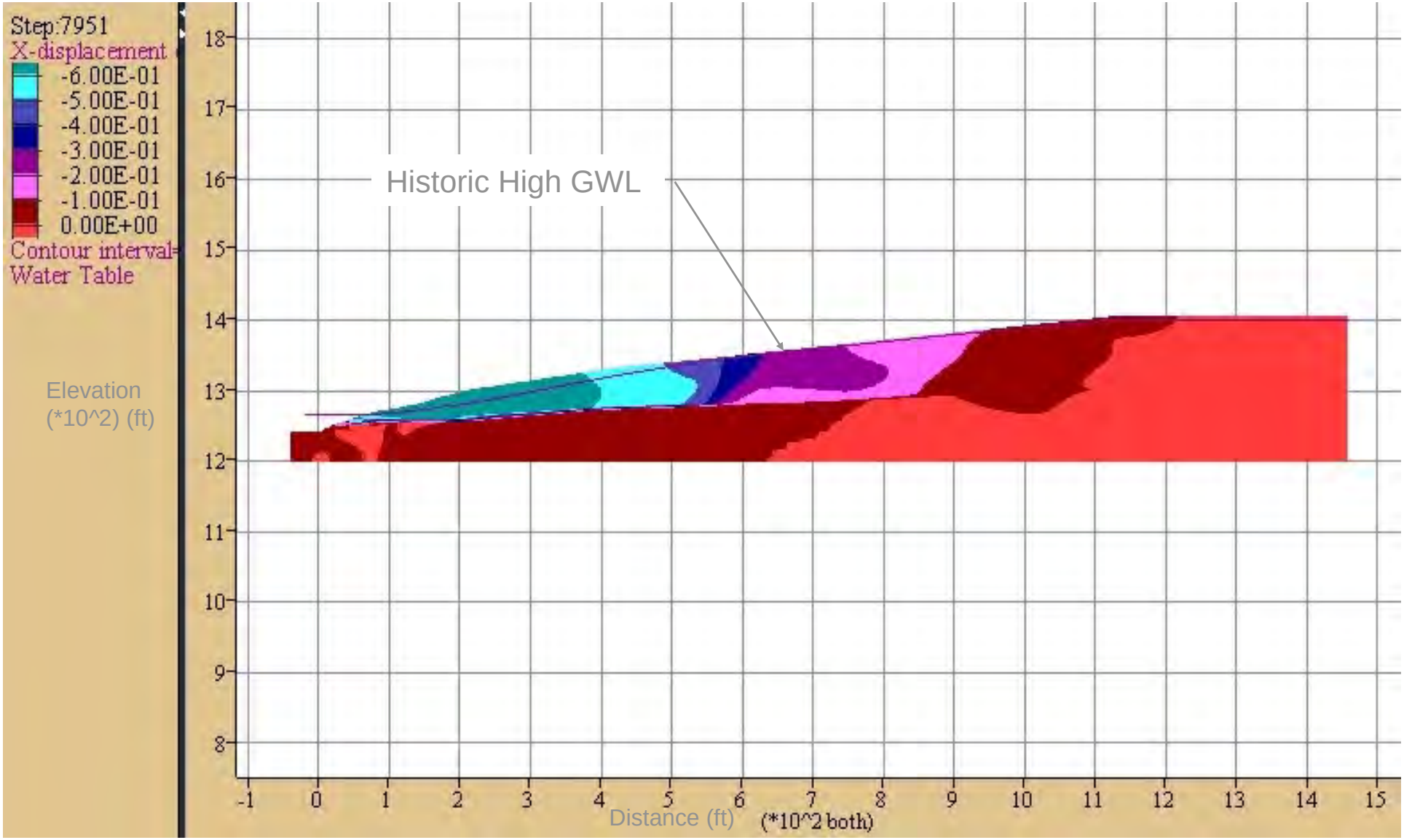
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FLAC: Pre-1996 Wall



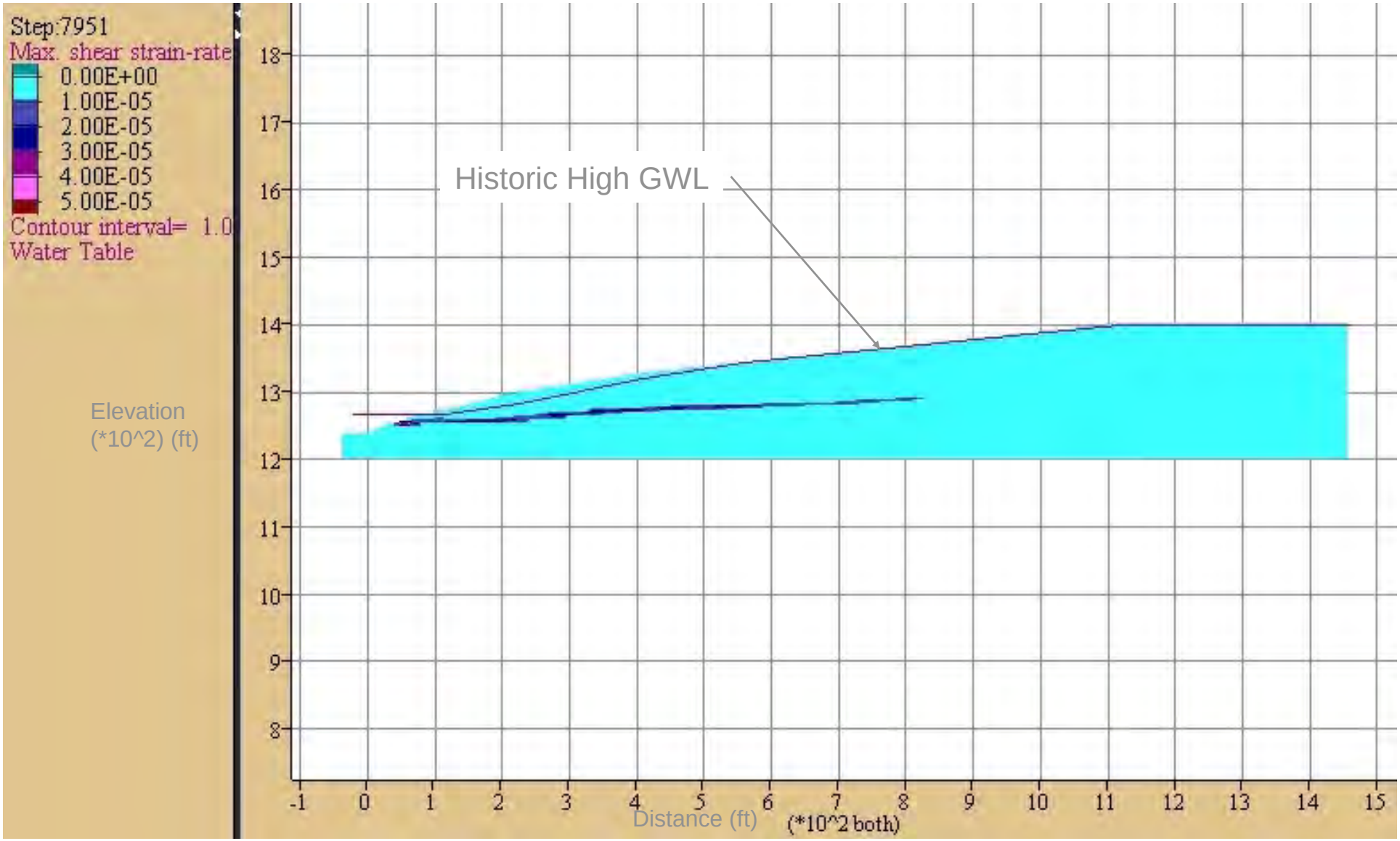
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FLAC: Pre-1996 Wall



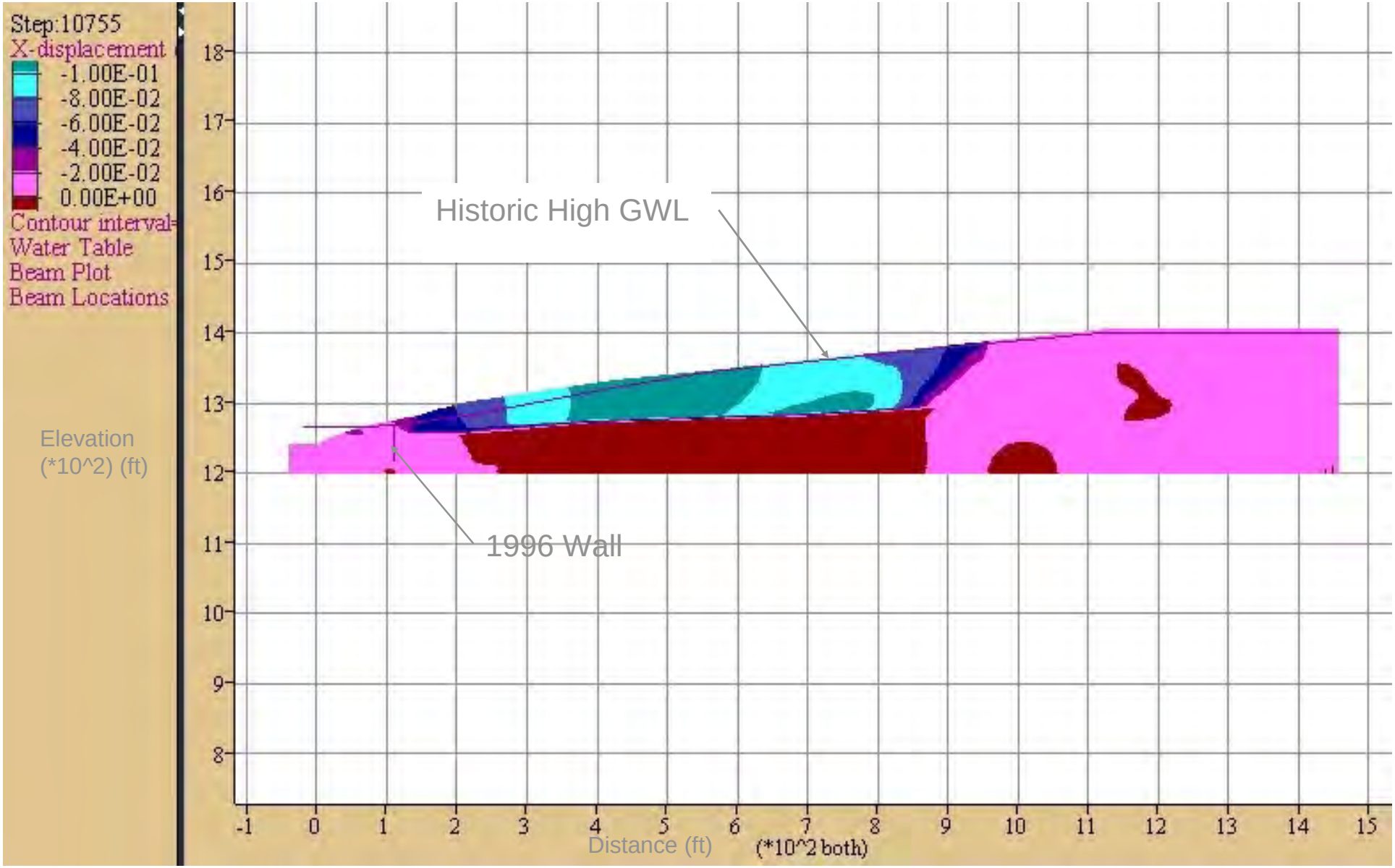
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FLAC: Pre-1996 Wall



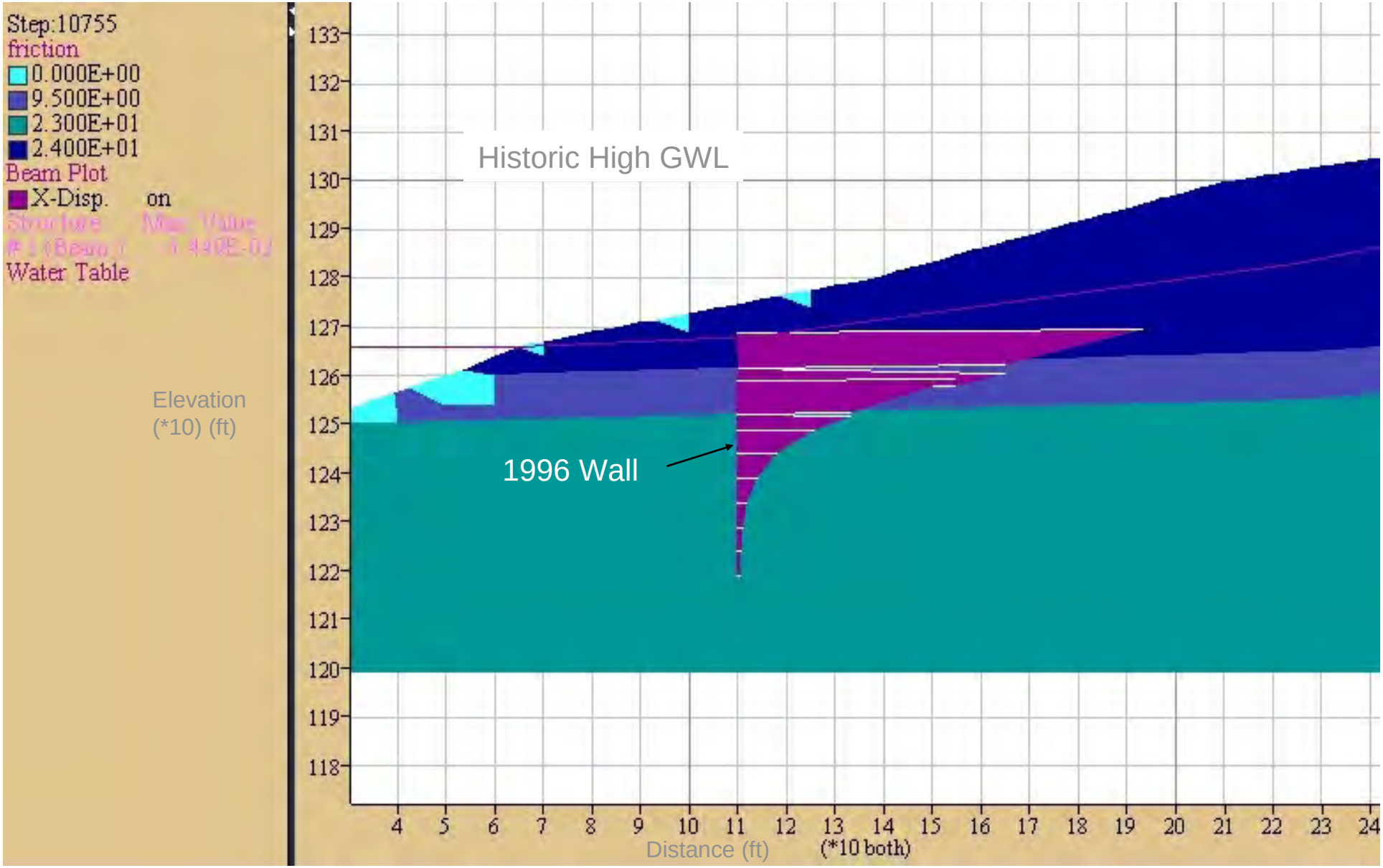
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FLAC: 1996 Wall



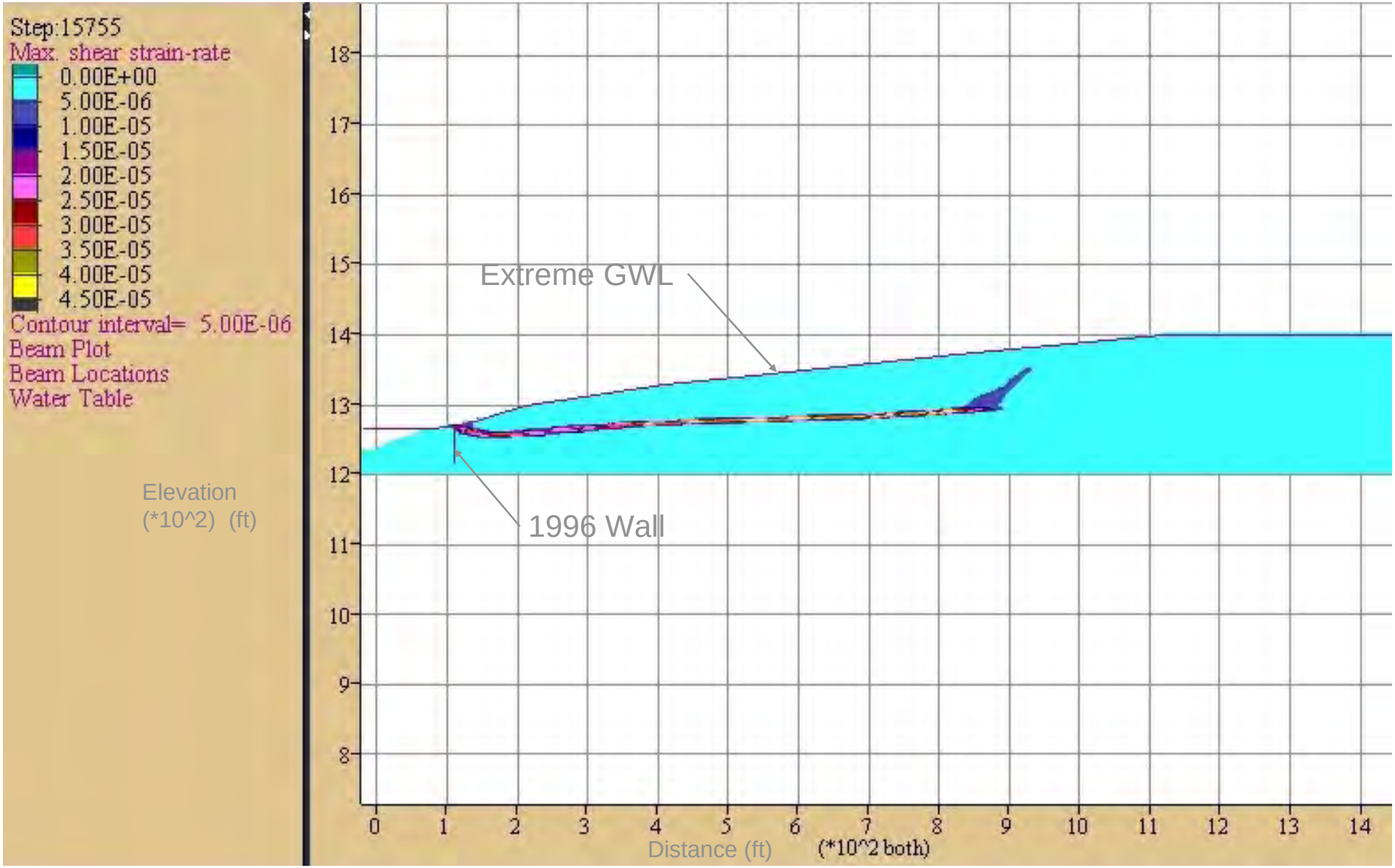
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FLAC: 1996 Wall



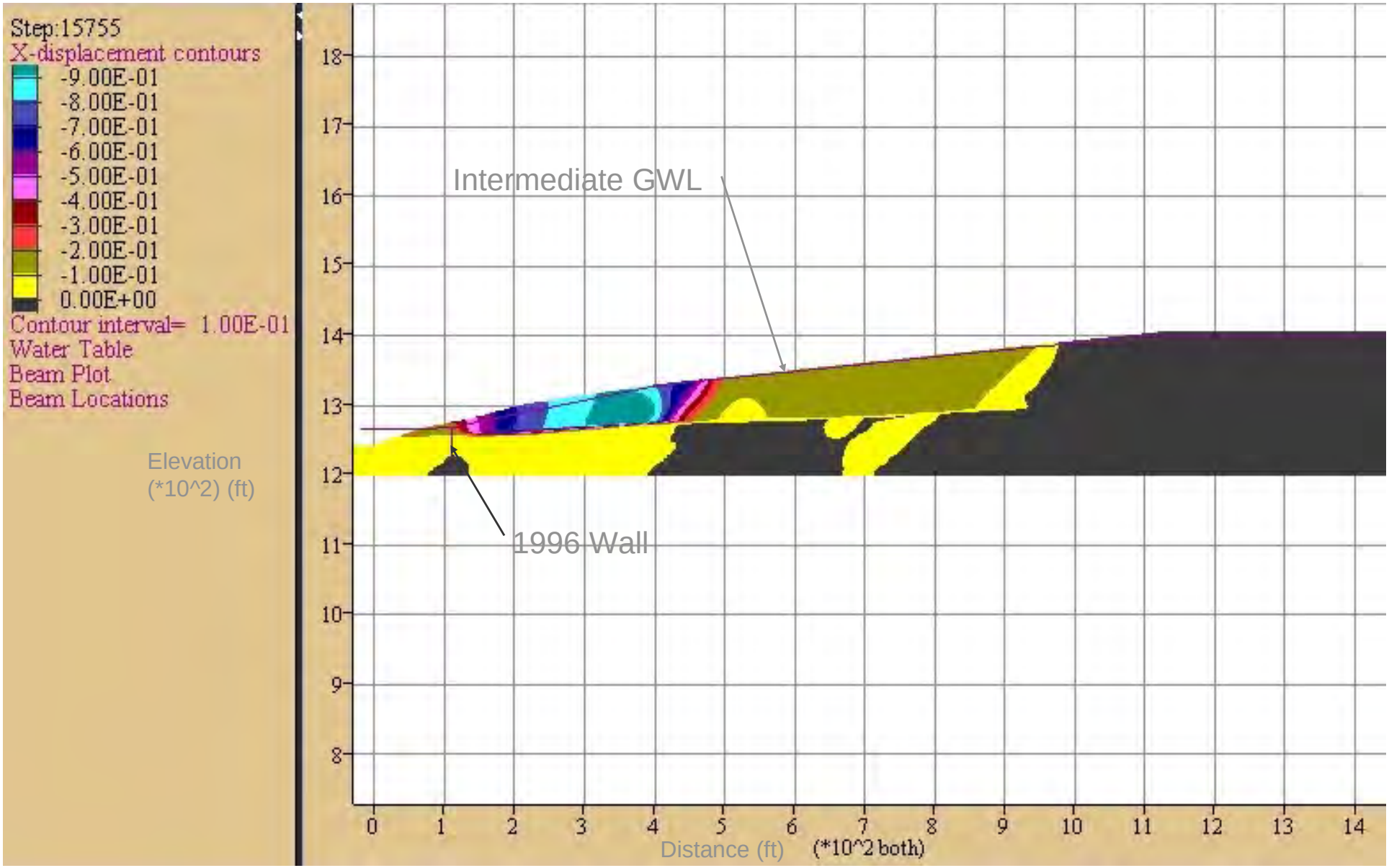
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FLAC: 1996 Wall



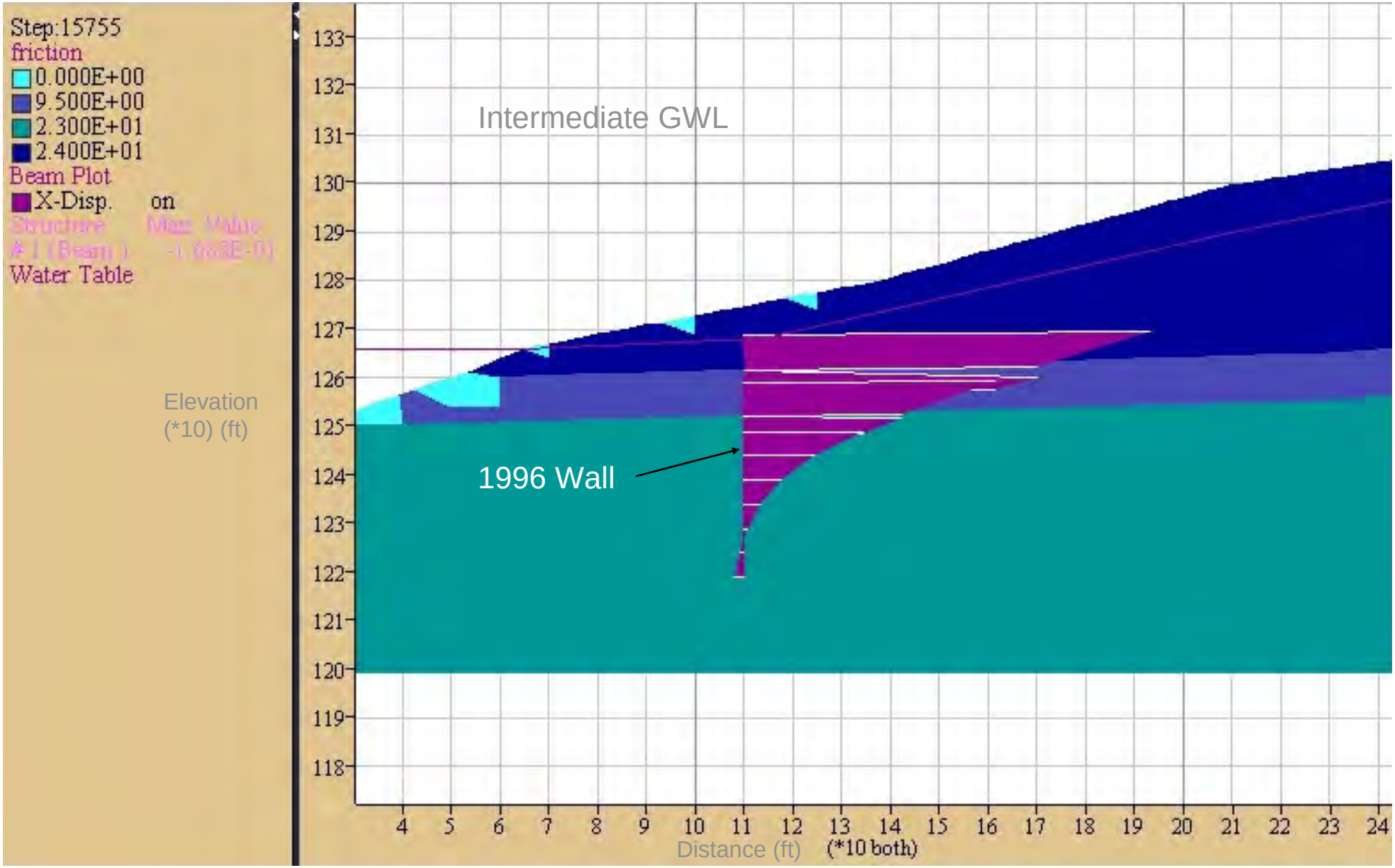
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FLAC: 1996 Wall



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FLAC: 1996 Wall



Summary

- History of problems
- Instrumentation extremely important
  - ✓ Understanding mechanism of displacement
  - ✓ Identifying geometry of failure surface
- Pressuremeter testing (elastic properties)
- Laboratory testing (shear strength)
- Limit equilibrium (back calculation)

Summary (con't)

FLAC results

- ✓ No searching for the critical failure surface
- ✓ Compute displacements with visual representation
- ✓ Helps in understanding problem
- ✓ General agreement with limit equilibrium results
- ✓ Abutment is stable to past historic high GWL's
- ✓ Abutment is at risk of failure to extreme GWL's
- ✓ At an intermediate GWL, abutment may be stable, but with much more deflection of the 1996 drilled shaft wall


QUESTIONS?

2-D Liquefaction Evaluation with *Q4Mesh*

-David C. Serafini, M.S., P.E.
US Army Corps of Engineers, Sacramento, CA

Presentation Outline

- Liquefaction Evaluation Overview
- Overview of Quad4m
- Overview of Q4Mesh
- Liquefaction Evaluation with Q4Mesh
- Example Q4Mesh Liquefaction Model

US Army Corps of Engineers
Sacramento District

Liquefaction Evaluation Overview

- Two-dimensional seismic response and liquefaction evaluations of earth structures and soil deposits can be complex and time intensive

- Techniques available for their evaluation range from simplified models to advanced constitutive and non-linear models

US Army Corps
of Engineers
Sacramento District

Liquefaction Evaluation Overview

- Simplified Models
  - Simplified Seed and Idriss procedures
  - 1-D equivalent linear SHAKE type analysis at multiple locations
  - Evaluations can be made quickly
- Advanced Models
  - Most accommodate the non-linear behavior of soils
  - Evaluations are more complex and time intensive
- Equivalent Linear Models
  - Can be used to approximate the actual nonlinear behavior of the soil
  - Quad4m (two-dimensional seismic response)

Overview of Quad4m

- Quad4m (A Computer Program For Evaluating The Seismic Response Of Soil Structures)
  - U.C.Davis, 1993
  - by Martin Byrd Hudson, I.M.Idriss, and Mohsen Beikae
- MODIFIED FROM QUAD4, 1973
  - by I.M. Idriss, J. Lysmer, R. Hwang and H. Bolton Seed

Overview of Quad4m

- The Quad4m analysis numerically models a continuum with a finite number of elements interconnected at their common nodes

- The analysis is done exclusively in the time domain, and the response of the soil deposit follows the same approximation of nonlinear hysteretic manner that is conventional SHAKE (1-D) analysis when subject to loading

Overview of Quad4m

- Direct numerical integration by the software is used to solve an equation of motion for the finite element mesh to determine the developed:
  - Peak Element Shear Stresses (sig-xy, τ_{max})
  - Peak Element Shearing Strains (eps, γ_{max})
  - Peak Element Principle Stresses (sig-x, sig-y)
  - Peak Nodal Accelerations (a_{max})

Overview of Q4Mesh

- The Q4Mesh program is a modification of the WinMesh program to create and analyze Quad4m data

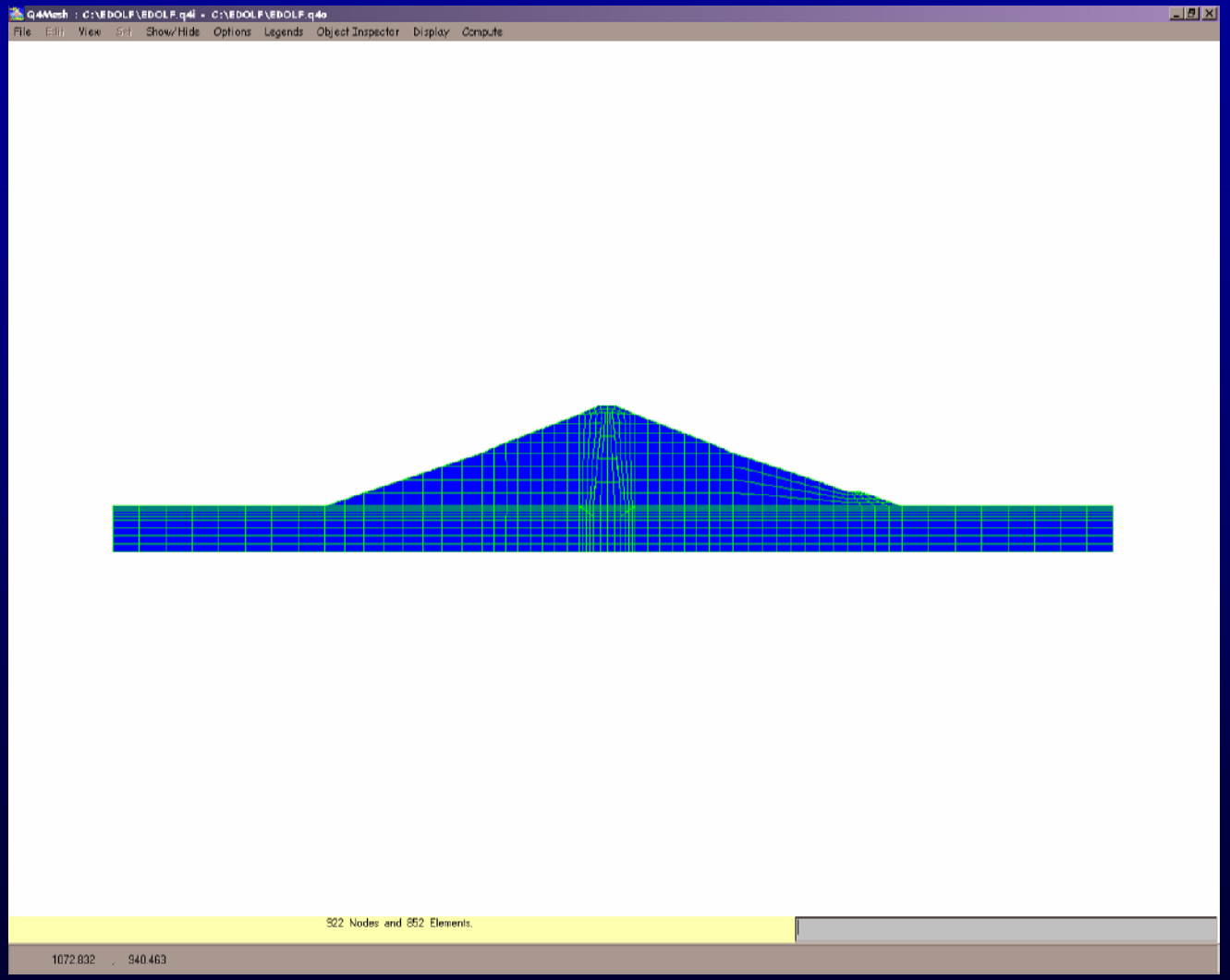
- Q4mesh was developed by ERDC (Engineering Research and Development Center) at WES (Waterways Experimental Station) with some assistance provided from the USACE Sacramento District

Overview of Q4Mesh

- Q4Mesh can be used to:
  - Create the Quad4m finite element mesh
  - Interpret the output files from Quad4m and two additional user files to conduct a liquefaction evaluation

Overview of Q4Mesh

- Q4Mesh
  - (Main Screen)



Overview of Q4Mesh

Additional Input Files for Q4Mesh

EDOLF_PHREATIC.dat - Notepad

File Edit Format Help

```
1) 6.75  0.28  0.0  1.0  135  130
2) 12
3) 700       550
   1000      550
   1131.3    590
   1221.6    625.0
   1316.9    662.5
   1387.8    691.5
   1410.3    691.5
   1576.5    625
   1739      570
   1754      570
   1815      550
   2114      550
4) 6
5) 700     662.5
   1316.9    662.5
   1389.2    653.25
   1415.75    582.875
   1439    550
   2114    550

1) magnitude, pga, fines (not used), factor of safety, sat_unit_weight, moist_unit_weight
2) Number of Ground Surface Points
3) Ground Surface X, Y Values
4) Number of Phreatic Surface Points
5) Phreatic Surface X, Y Values
```

Surface, Phreatic, and Earthquake File

EDOLF_N160_DATA.dat - Notepad

File Edit Format Help

```
1    50
2    50
3    50
4    45
5    50
6    50
7    50
8    10
9    15
10    20
11    10
12    15
13    20
14    60
Layer    Blowcount
```

Blowcount File

Overview of Q4Mesh

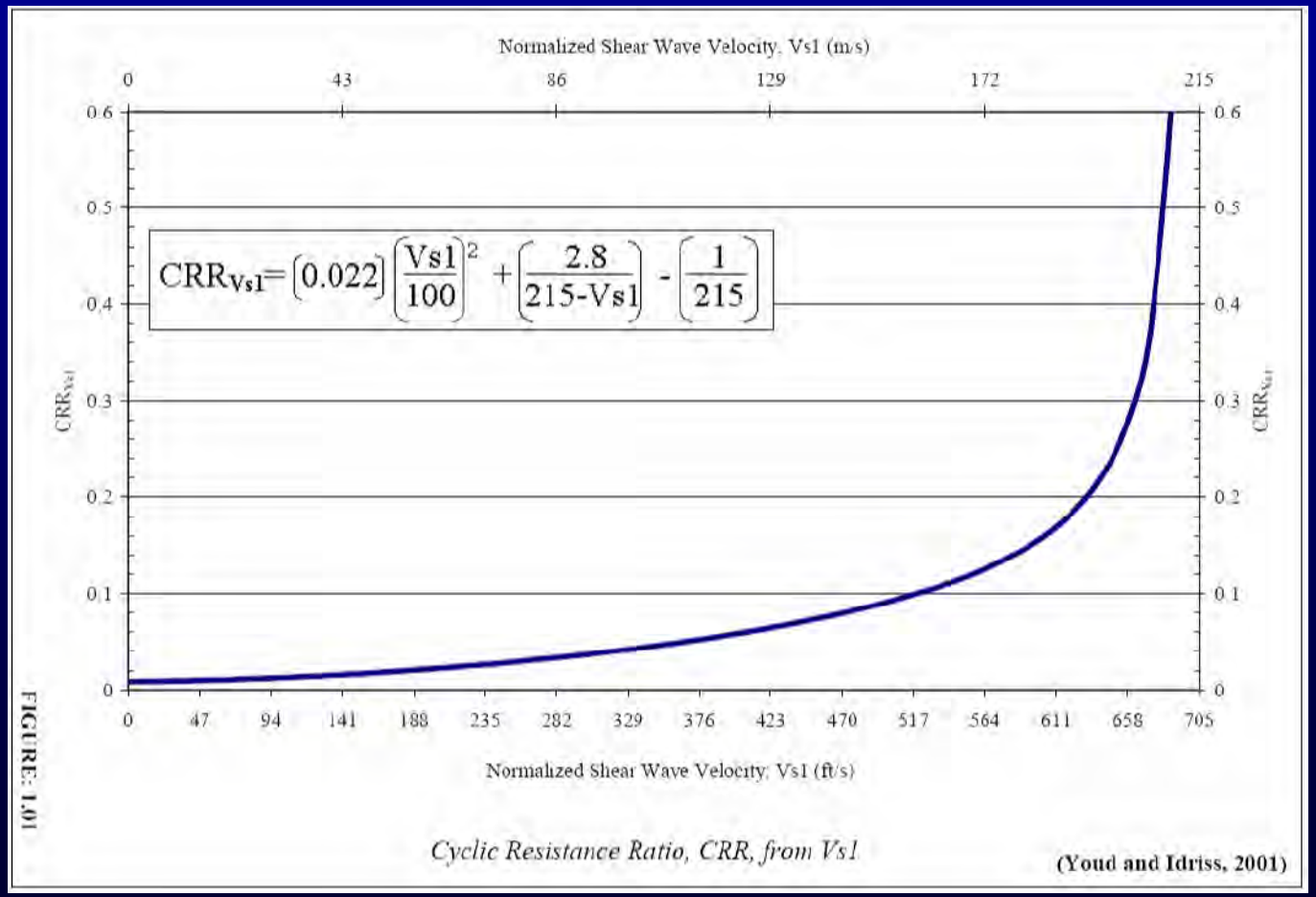
- Basic Liquefaction Procedure Equation

$$F.S._{LIQ} = \left(\frac{CRR_{()}}{CSR_{()}}\right)[MSF][k_\sigma][K_\alpha]$$

CSR (Cyclic Stress Ratio)
CRR (Cyclic Resistance Ratio)
Kσ (Stress Correction
Kα (Sloping Ground Correction)
MSF (Magnitude Scaling Factor)

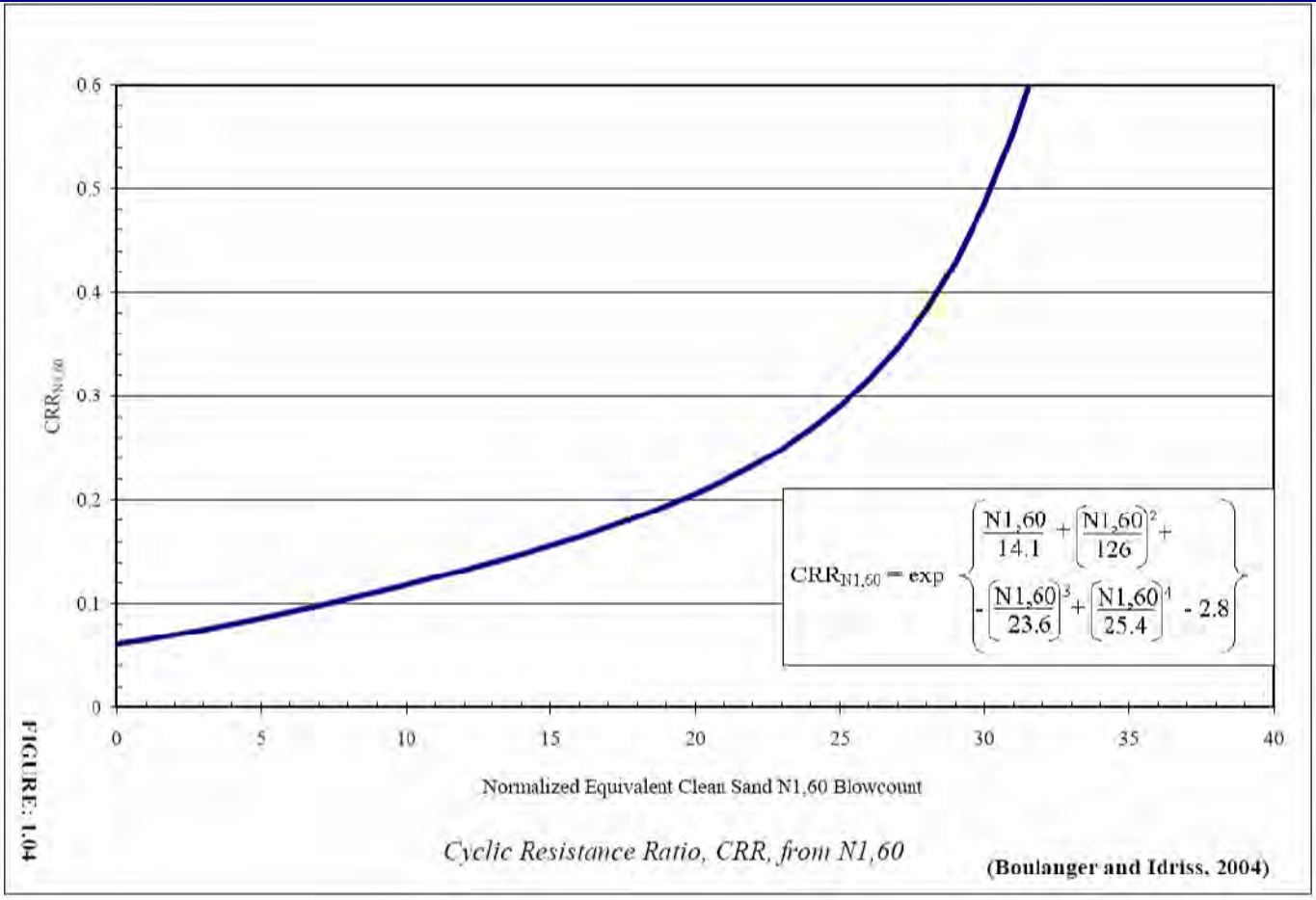
Example Q4Mesh Liquefaction Model

- Cyclic Resistance Ratio, CRR (Vs1 Data)



Example Q4Mesh Liquefaction Model

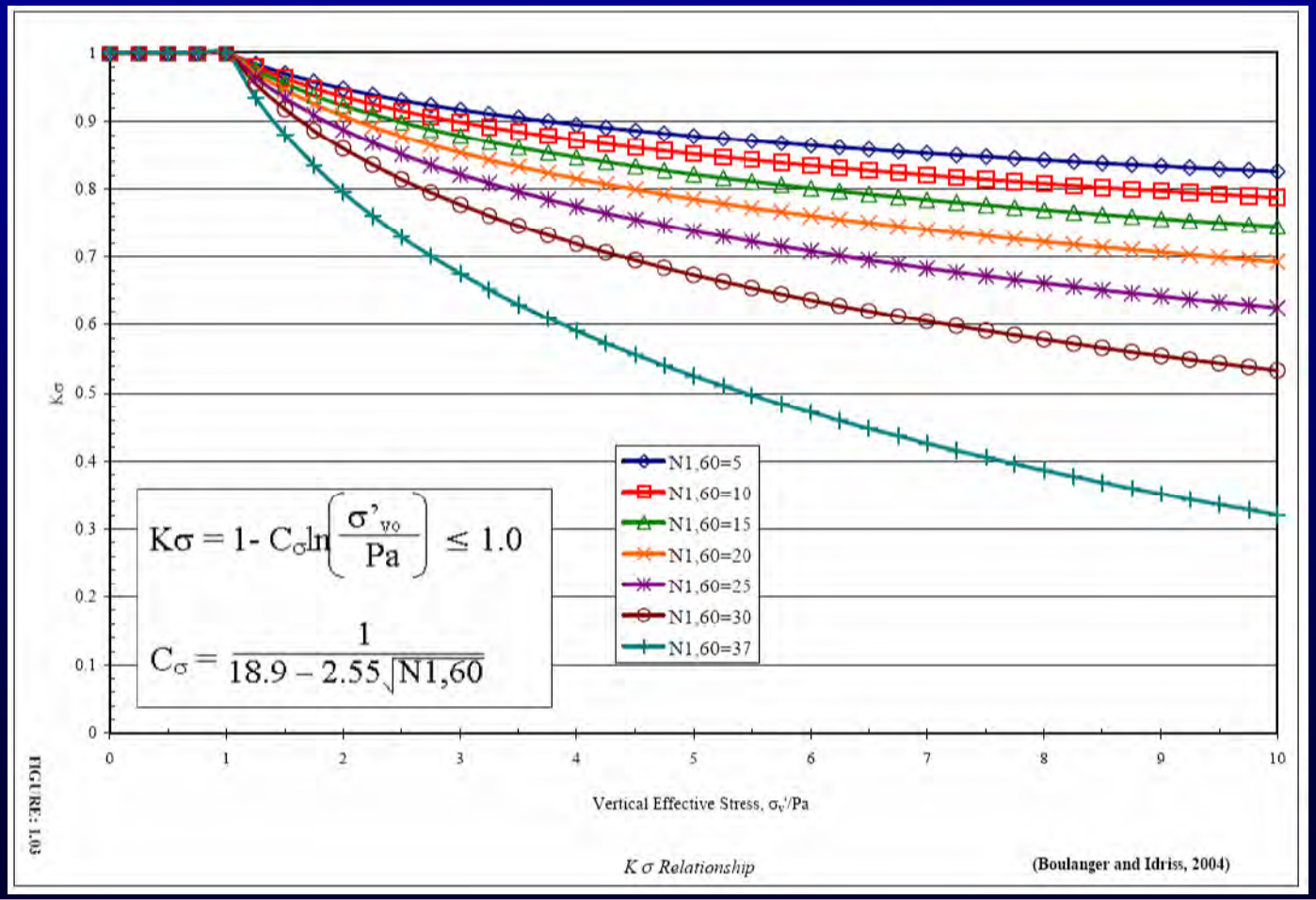
- Cyclic Resistance Ratio, CRR (N1,60 Data)



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Example Q4Mesh Liquefaction Model

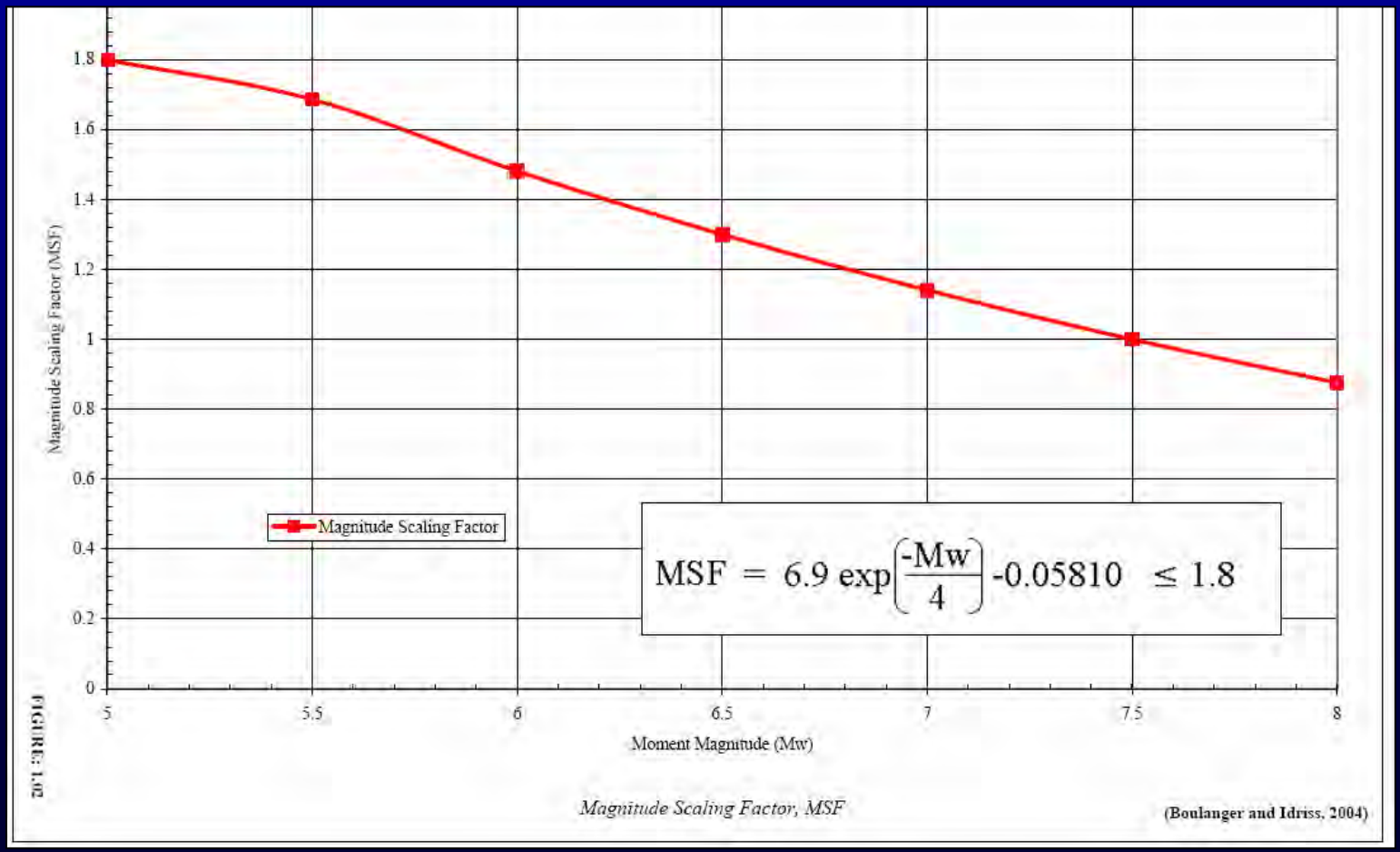
- Stress Correction Factor, Kσ



Default
Kα=1.0

Example Q4Mesh Liquefaction Model

- Magnitude Scaling Factor (MSF)



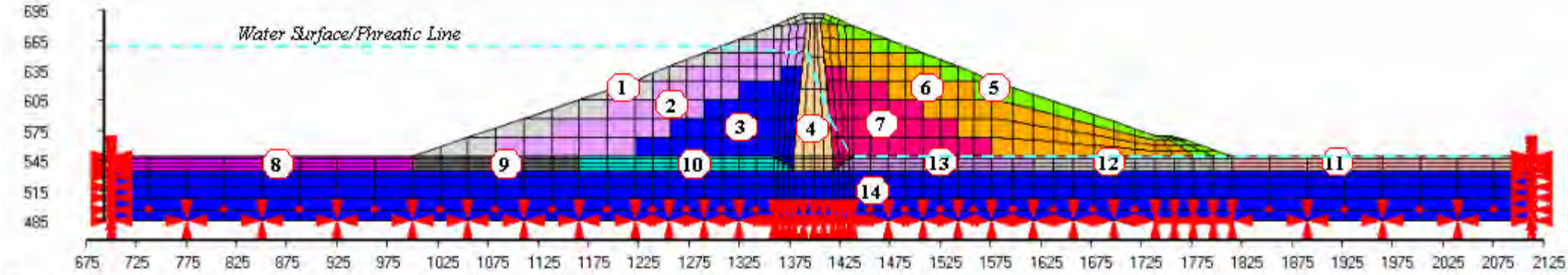
Example Q4Mesh Liquefaction Model

Embankment Dam on a Liquefiable Foundation (EDOLF)

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of Engineers
Sacramento District

Example Q4Mesh Liquefaction Model

- Finite Element Mesh



Embankment Dam on Liquefiable Foundation (EDOLF)

- Finite Element Mesh with Zones
- Location of Water Surface/Phreatic Surface
- Boundary Conditions

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Example Q4Mesh Liquefaction Model

- Material Properties

Material Properties:

Zone	Material	Vs (ft/s)	$(N_1)_{60}$	Shear Modulus Degradation Curve	Material Damping Curve
1	Embankment Shell	800	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
2	Embankment Shell	1000	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
3	Embankment Shell	1200	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
4	Core	1200	45	Clay (PI=10-20 Sun et al. 1988)	Clay Average (Seed & Idriss 1970)
5	Embankment Shell	800	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
6	Embankment Shell	1000	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
7	Embankment Shell	1200	50	Sand Upper Bound (Seed & Idriss 1970)	Sand Upper Bound (Seed & Idriss 1970)
8	Recent Alluvium	450	10	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
9	Recent Alluvium	550	15	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
10	Recent Alluvium	650	20	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
11	Recent Alluvium	450	10	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
12	Recent Alluvium	550	15	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
13	Recent Alluvium	650	20	Sand Average (Seed & Idriss 1970)	Sand Average (Seed & Idriss 1970)
14	Older Alluvium	2000	60	Clay Upper Range (Idriss, 1990)	Clay (Idriss, 1990)

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Sacramento District

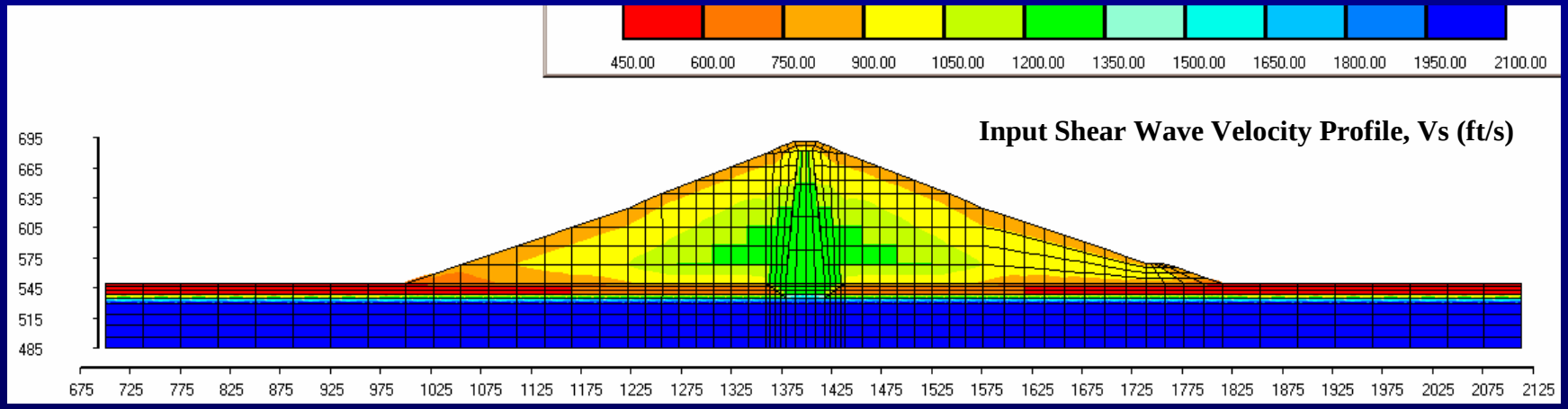
Example Q4Mesh Liquefaction Model

- Input Earthquake Record
  - IMPERIAL VALLEY EARTHQUAKE, CA; OCT 15, 1979
  - Mw=6.75 at 22km
  - Amax=0.28g
  - Filtered Record Low-Pass=20hz
  - Bracketed Duration ~22 seconds
  - "ROCK OUTCROP MOTION"

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Example Q4Mesh Liquefaction Model

- Input Shear Wave Velocities

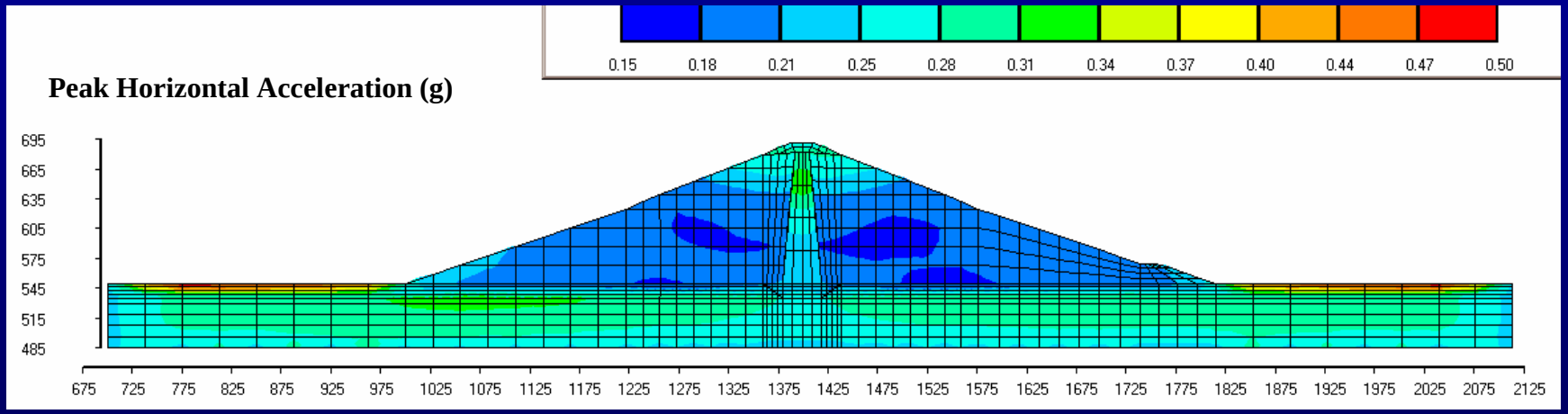


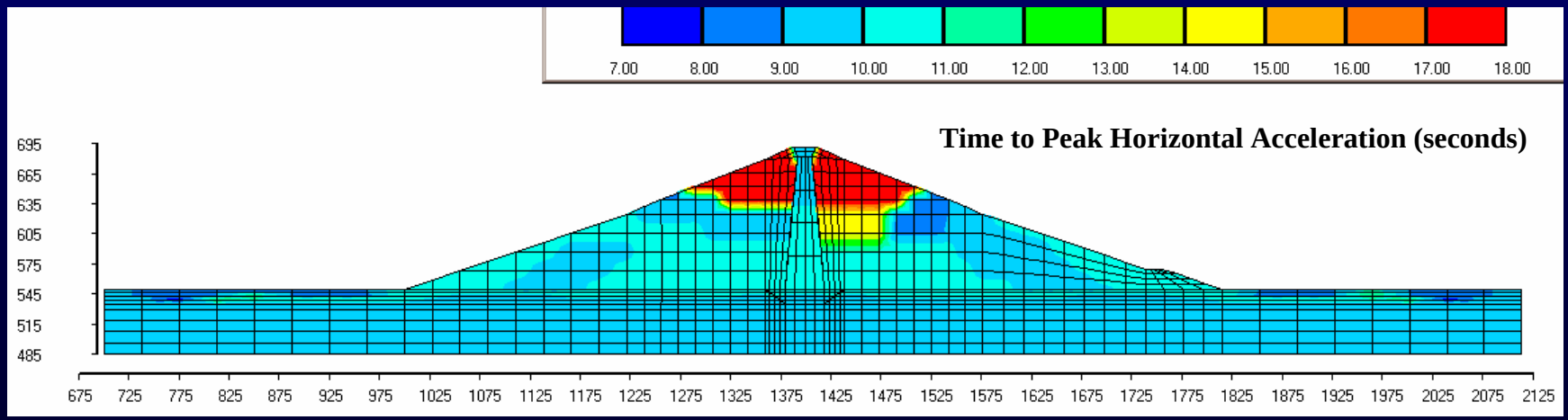
Example Q4Mesh Liquefaction Model

Quad4m Analysis Results

Example Q4Mesh Liquefaction Model

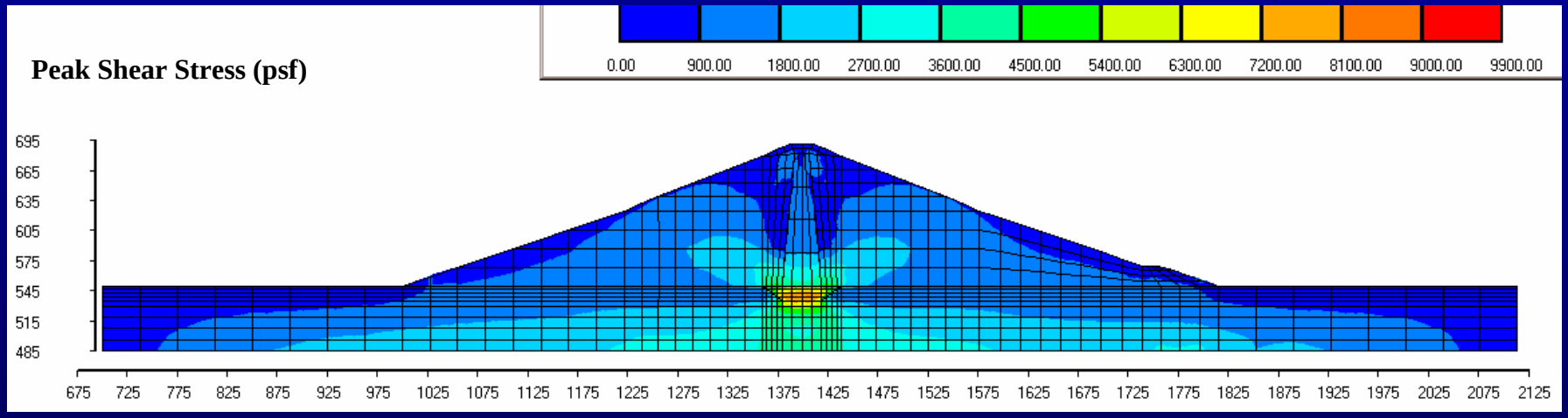
- Peak Nodal Horizontal Acceleration (g)

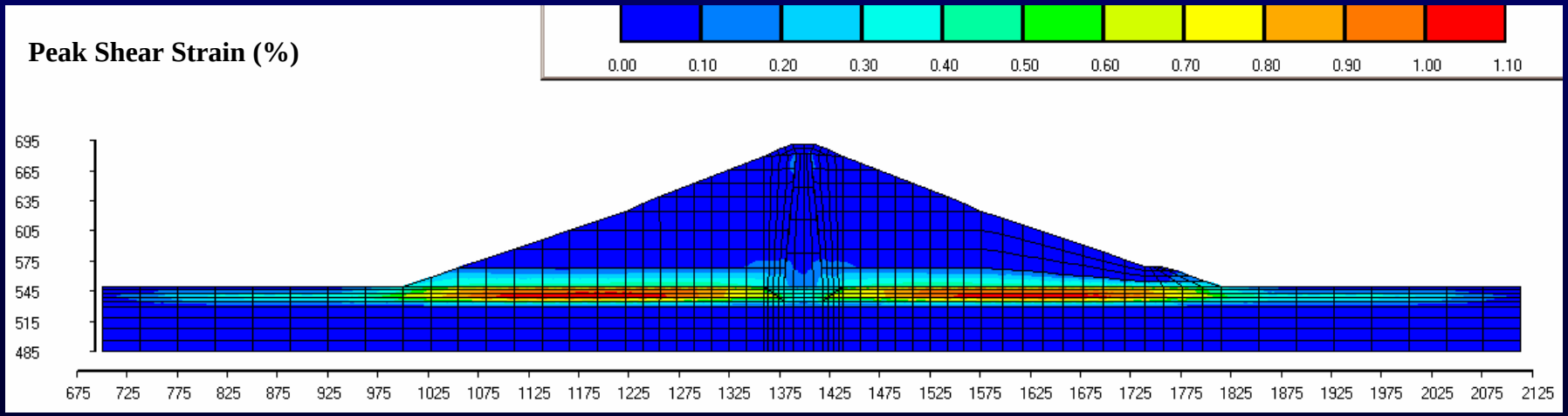




Example Q4Mesh Liquefaction Model

- Peak Element Induced Shear Stress and Strain

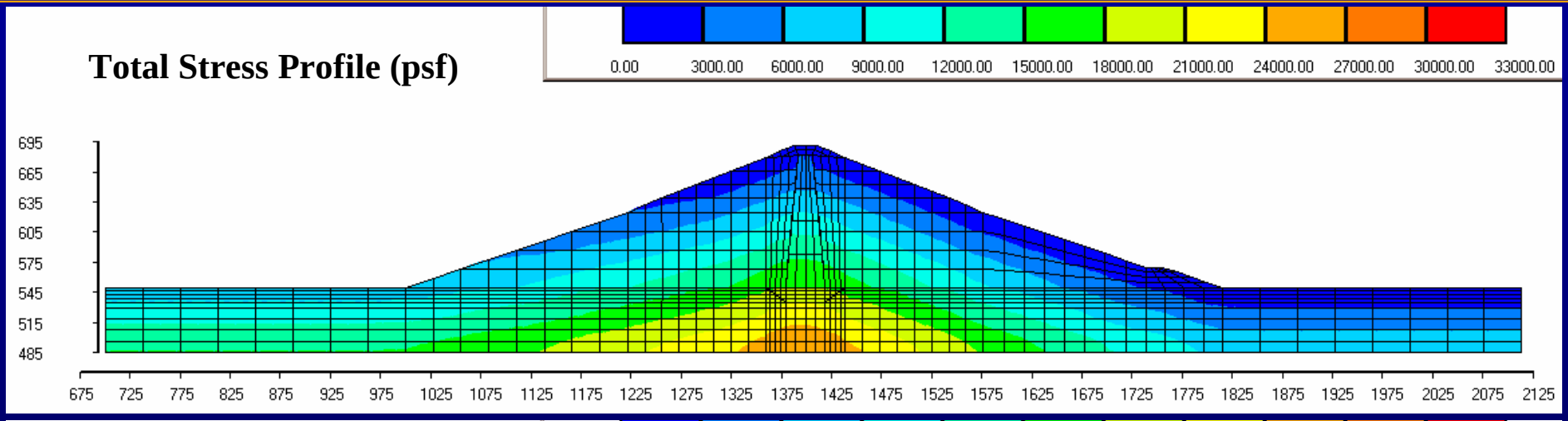


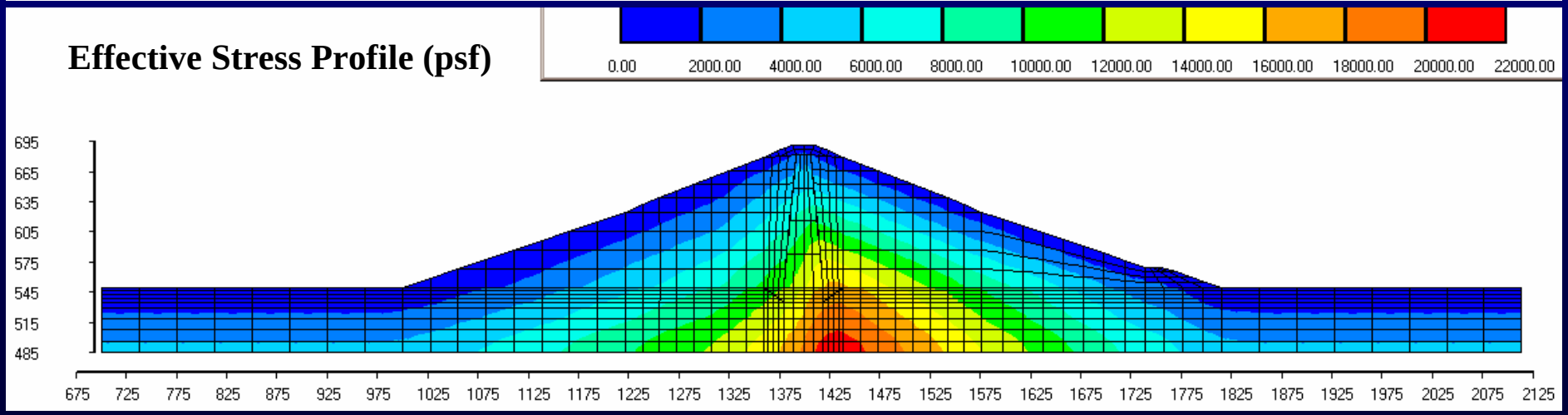


Example Q4Mesh Liquefaction Model

Q4Mesh Analysis and Results

Example Model



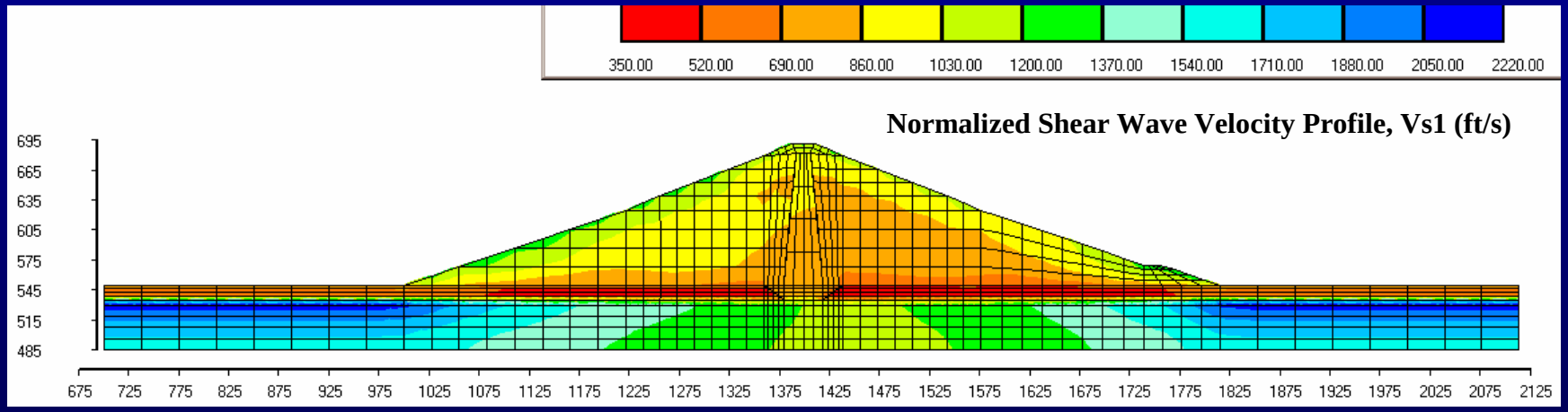


Given: γ_{sat} =135pcf, γ_{moist} =130pcf for all elements

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Example Q4Mesh Liquefaction Model

- Normalized Shear Wave Velocities



$$Vs1 = [Vs]\left(\frac{Pa}{\sigma_{vo}'}\right)^{0.25}$$

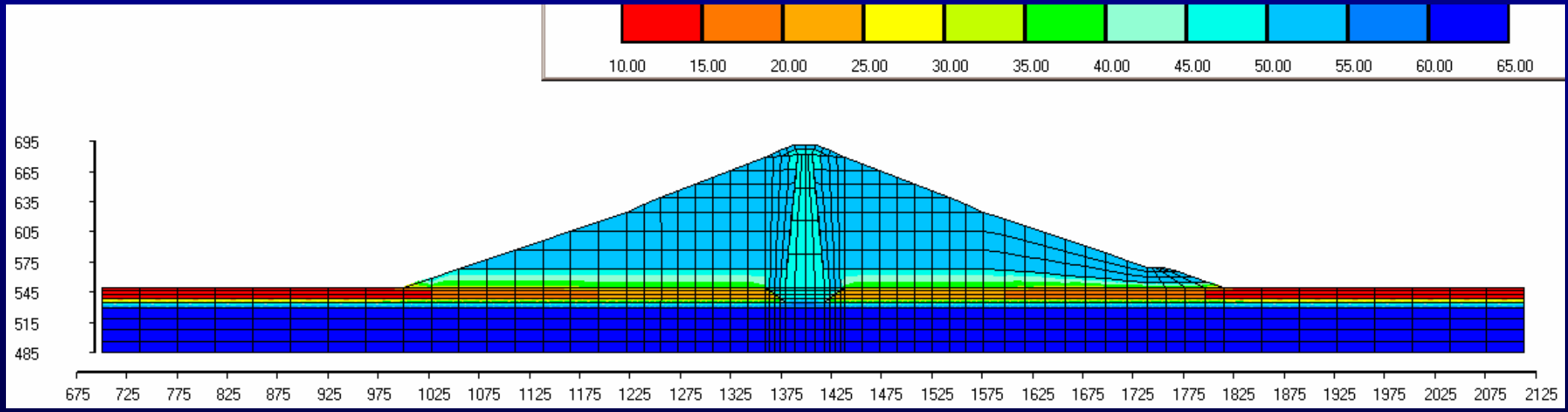
Pa = Reference Stress of 2000 psf

σ_{vo}' = Vertical Effective stress, Calculated using Q4MESH

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Example Q4Mesh Liquefaction Model

- Input Blowcount Data, $(N_1)_{60}$ (blows/ft)



Example Q4Mesh Liquefaction Model

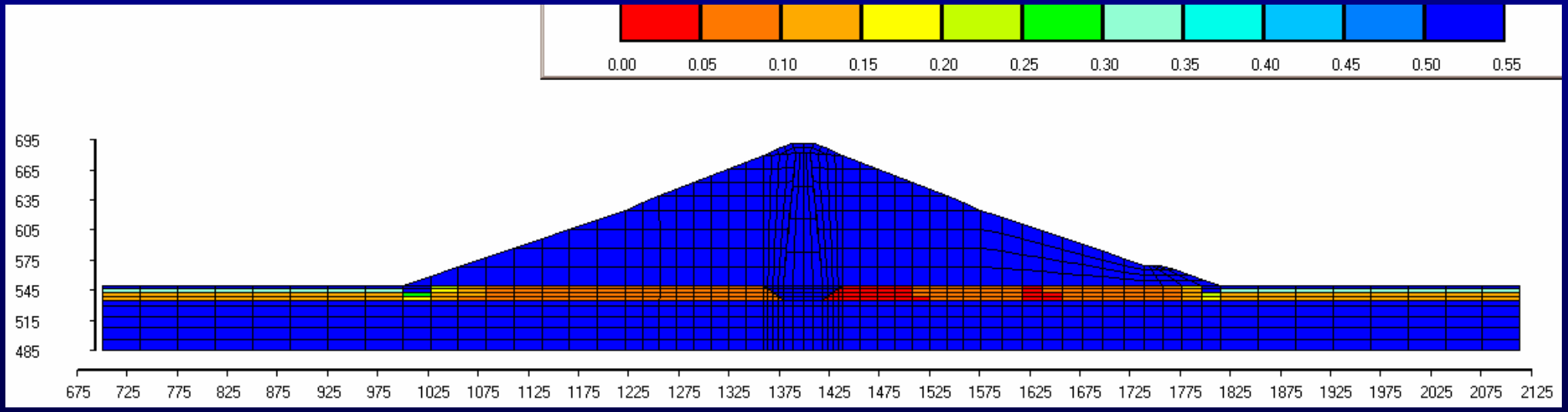
Cyclic Resistance Ratio CRR

- Vs1 Values
- $(N_1)_{60}$ Blowcount Values

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Example Q4Mesh Liquefaction Model

- Cyclic Resistance Ratio, CRR
  - (Calculated from the Vs1 Values)



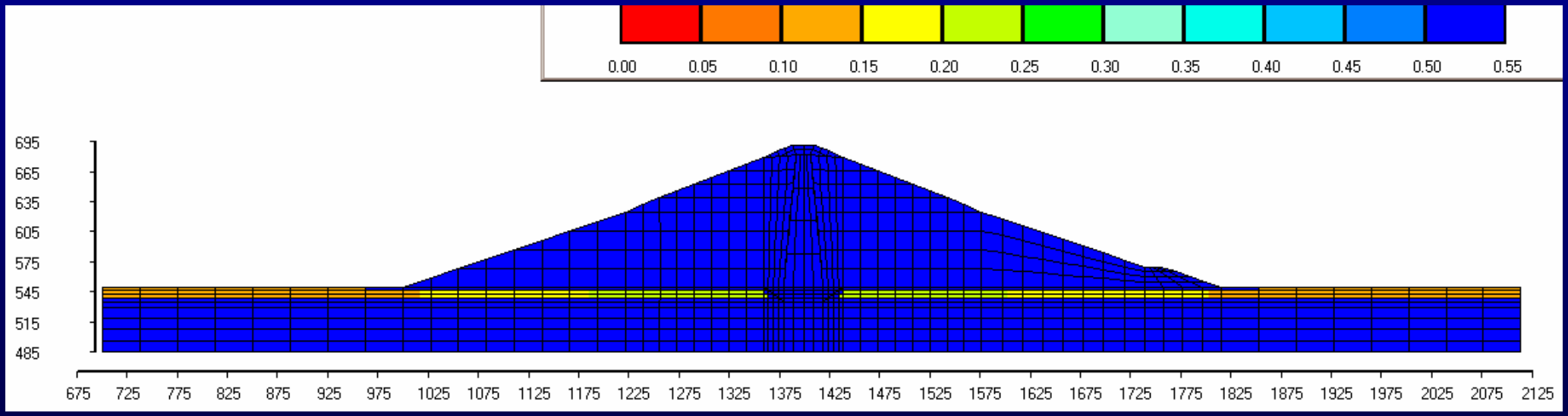
$$CRR_{Vs1} = [0.022]\left(\frac{Vs1}{100}\right)^2 + \left(\frac{2.8}{215\text{-}Vs1}\right) - \left(\frac{2.8}{215}\right)$$

NCEER Workshop

Andrus and Stokoe (1997)

Example Q4Mesh Liquefaction Model

- Cyclic Resistance Ratio, CRR
  - (Calculated from the $(N_1)_{60}$ Values)



$$CRR_{N1,60} = \exp\left\{\frac{N1,60}{14.1} + \left(\frac{N1,60}{126}\right)^2 + \left(\frac{N1,60}{23.6}\right)^3 + \left(\frac{N1,60}{25.4}\right)^4 - 2.8\right\}$$

ICSDEE and ICEGE Conference

Idriss and Boulanger (2004)

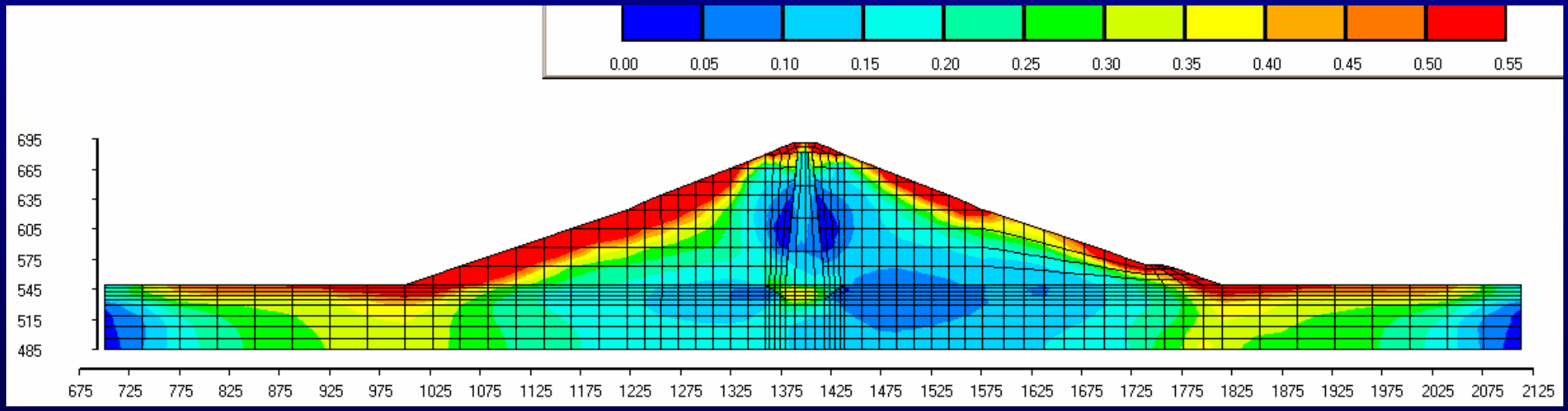
Example Q4Mesh Liquefaction Model

Cyclic Stress Ratio CSR

- Peak Element Stresses
- Seed and Idriss Simplified Procedure

Example Q4Mesh Liquefaction Model

- Cyclic Stress Ratio, CSR
  - (Calculated from Quad4m Peak Induced Shear Stresses)



$$CSR = \frac{(0.65)(\tau_{max})}{(\sigma_{vo}')}$$

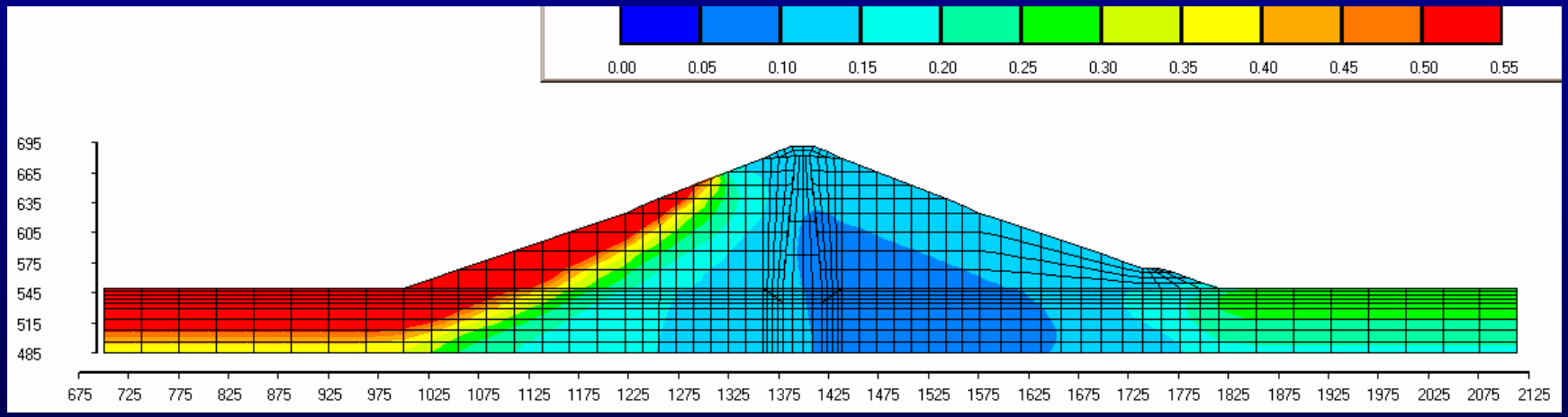
τ_{max} = Peak Element Shear Stress from Quad4m

σ_{vo}' = Vertical Effective stress, Calculated using Q4MESH

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Example Q4Mesh Liquefaction Model

- Cyclic Stress Ratio, CSR
  - (Calculated from Simplified Procedure)



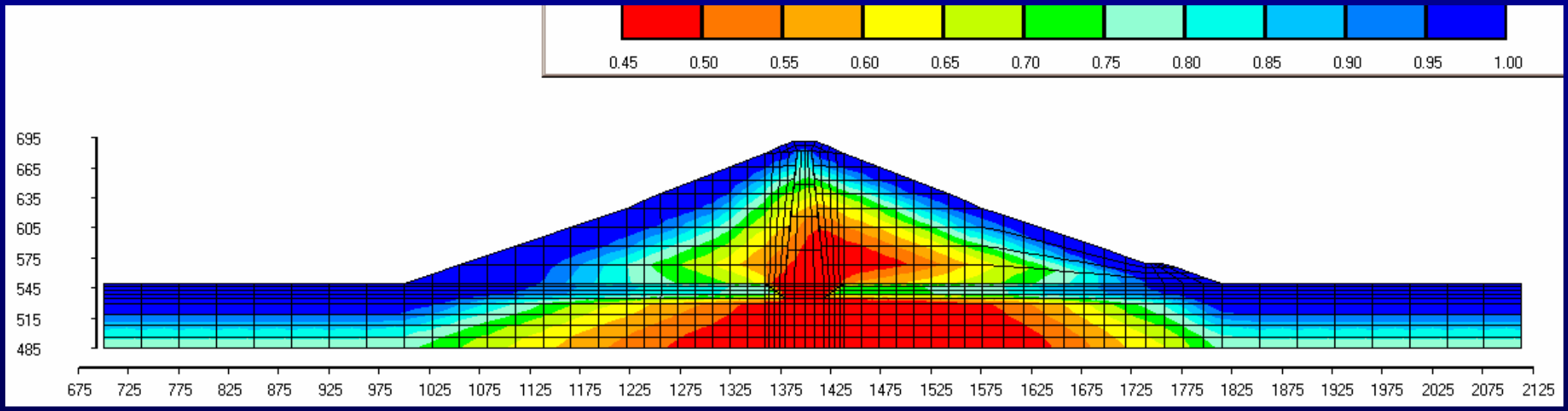
$$CSR = (\tau_{av}/\sigma'_{vo}) = 0.65(a_{max}/g)(\sigma_{vo}/\sigma'_{vo})rd$$

Parameters as Defined by Youd and Idriss 2001

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Example Q4Mesh Liquefaction Model

- Stress Correction Factor, Kσ



$$K\sigma = 1\text{-}C_\sigma \ln\left(\frac{\sigma'_{vo}}{Pa}\right) \leq 1.0$$

$$C_\sigma = \frac{1}{18.9 - 2.55\sqrt{N1,60}}$$

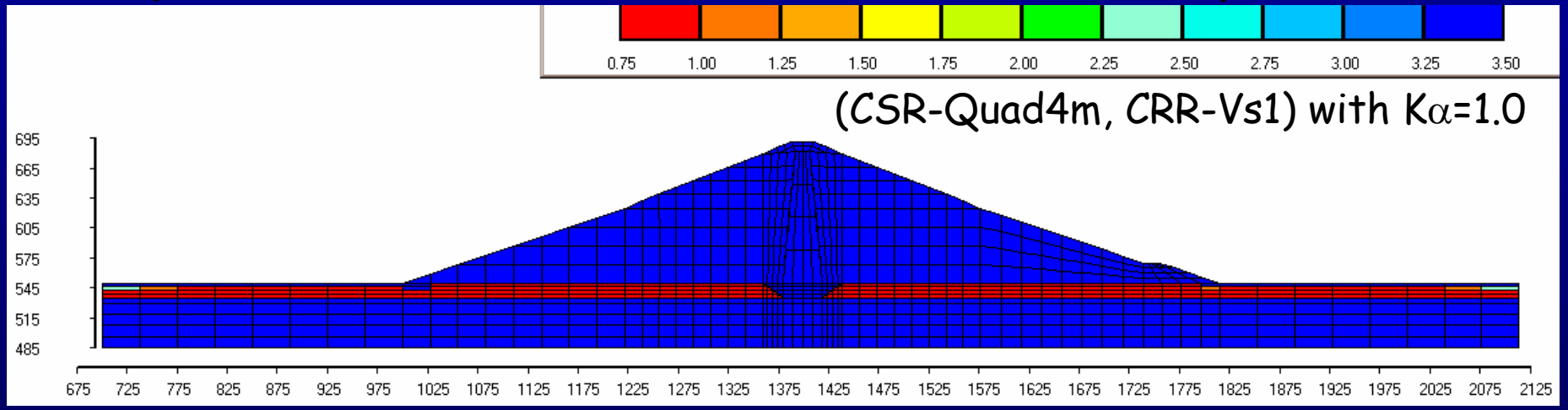
ICSDEE and ICEGE Conference

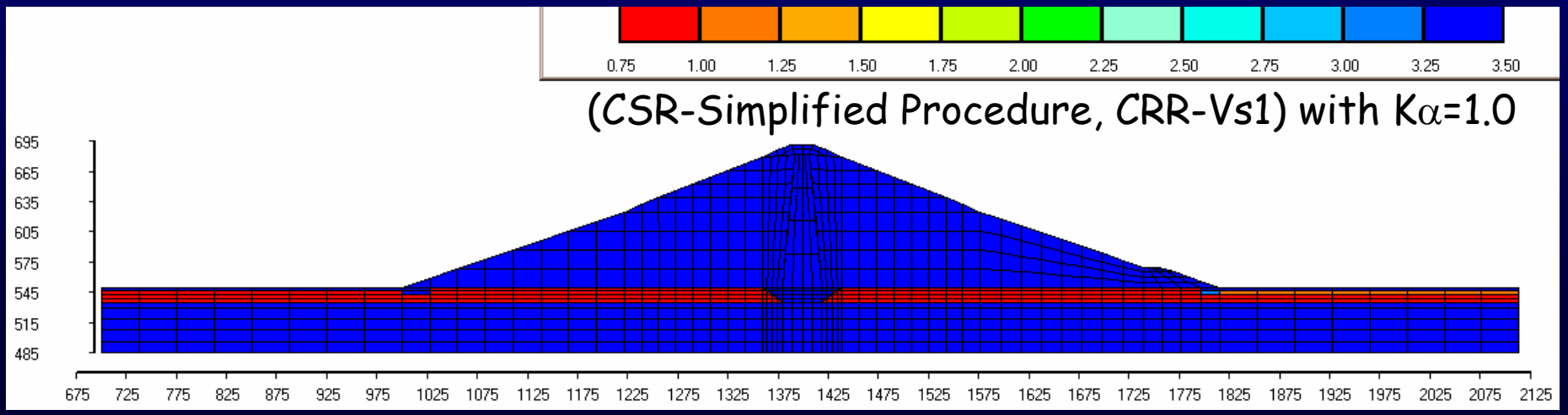
Idriss and Boulanger (2004)

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Example Q4Mesh Liquefaction Model

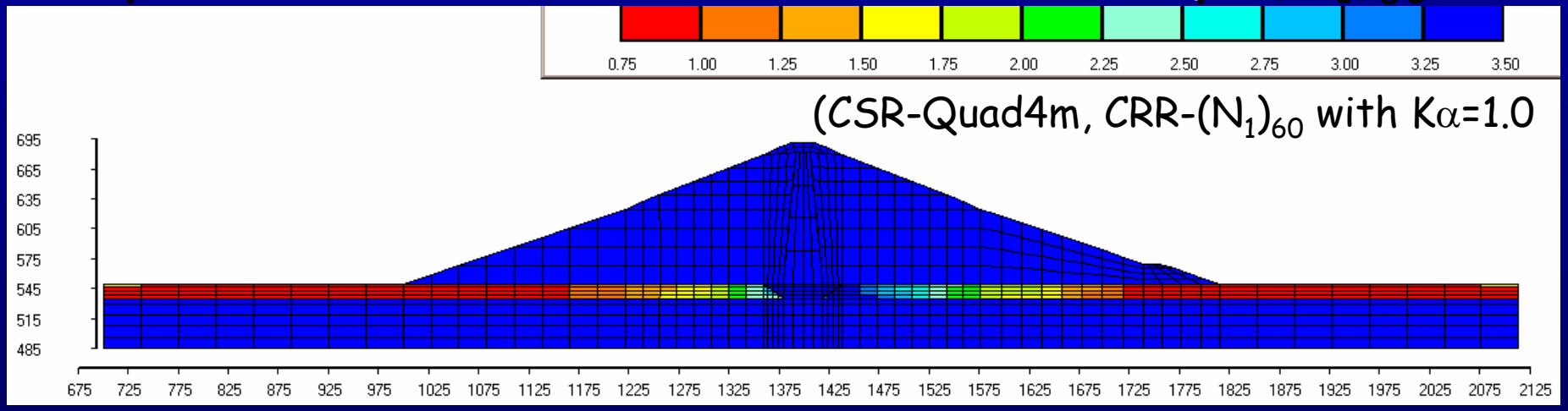
- Liquefaction Potential Factor of Safety, Vs_1 Data

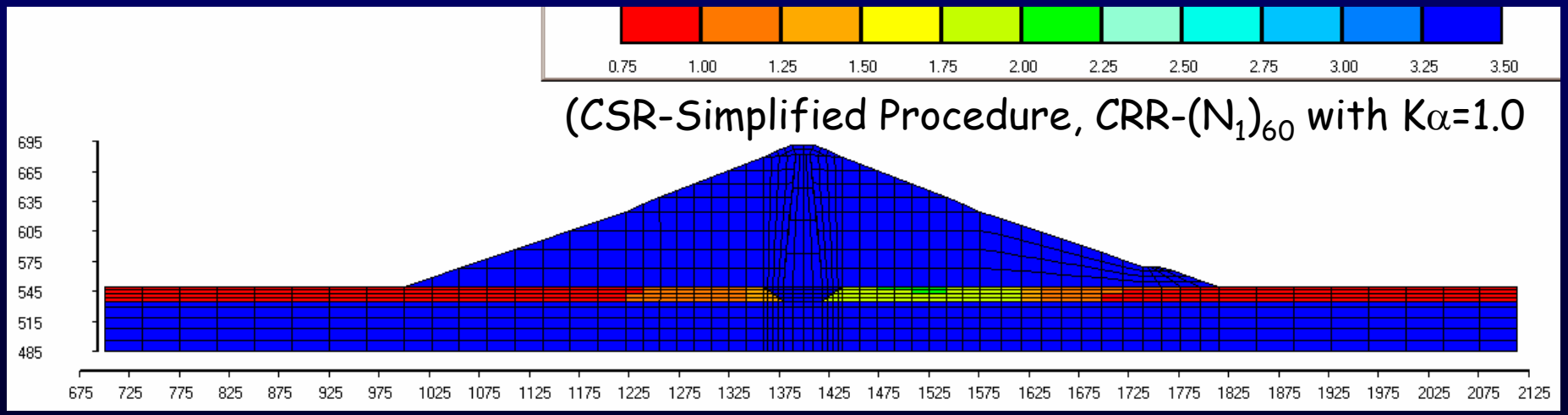




Example Q4Mesh Liquefaction Model

- Liquefaction Potential Factor of Safety, $(N_1)_{60}$ Data





Concluding Remarks

- Q4Mesh enables the ability to conduct 2-D liquefaction potential evaluations from Quad4m output data
- Quad4m and Q4Mesh can be used as a first step evaluation before more advanced models are implemented
- User experience and correct model generation is important when evaluating the Quad4m output files

References

- Idriss, I. M., and Boulanger, R. W. (2004). "Semi-empirical procedures for evaluating liquefaction potential during earthquakes." Proc., 11th International Conference on Soil Dynamics and Earthquake Engineering, and 3rd International Conference on Earthquake Geotechnical Engineering, D. Doolin et al., eds., Stallion Press, Vol. 1, 32-56.

- Boulanger, R. W. and Idriss, I. M. (2004). "State normalization of penetration resistances and the effect of overburden stress on liquefaction resistance." Proc., 11th International Conference on Soil Dynamics and Earthquake Engineering, and 3rd International Conference on Earthquake Geotechnical Engineering, D. Doolin et al., eds., Stallion Press, Vol. 2, 484-491.

- Youd, T. L. and Idriss, I. M. (2001). "Liquefaction resistance of soils: summary report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 127, No. 4, pp. 297-313.

2005 Tri-Service Infrastructure Systems Conference and Exhibition

Thank you!

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Contact Information

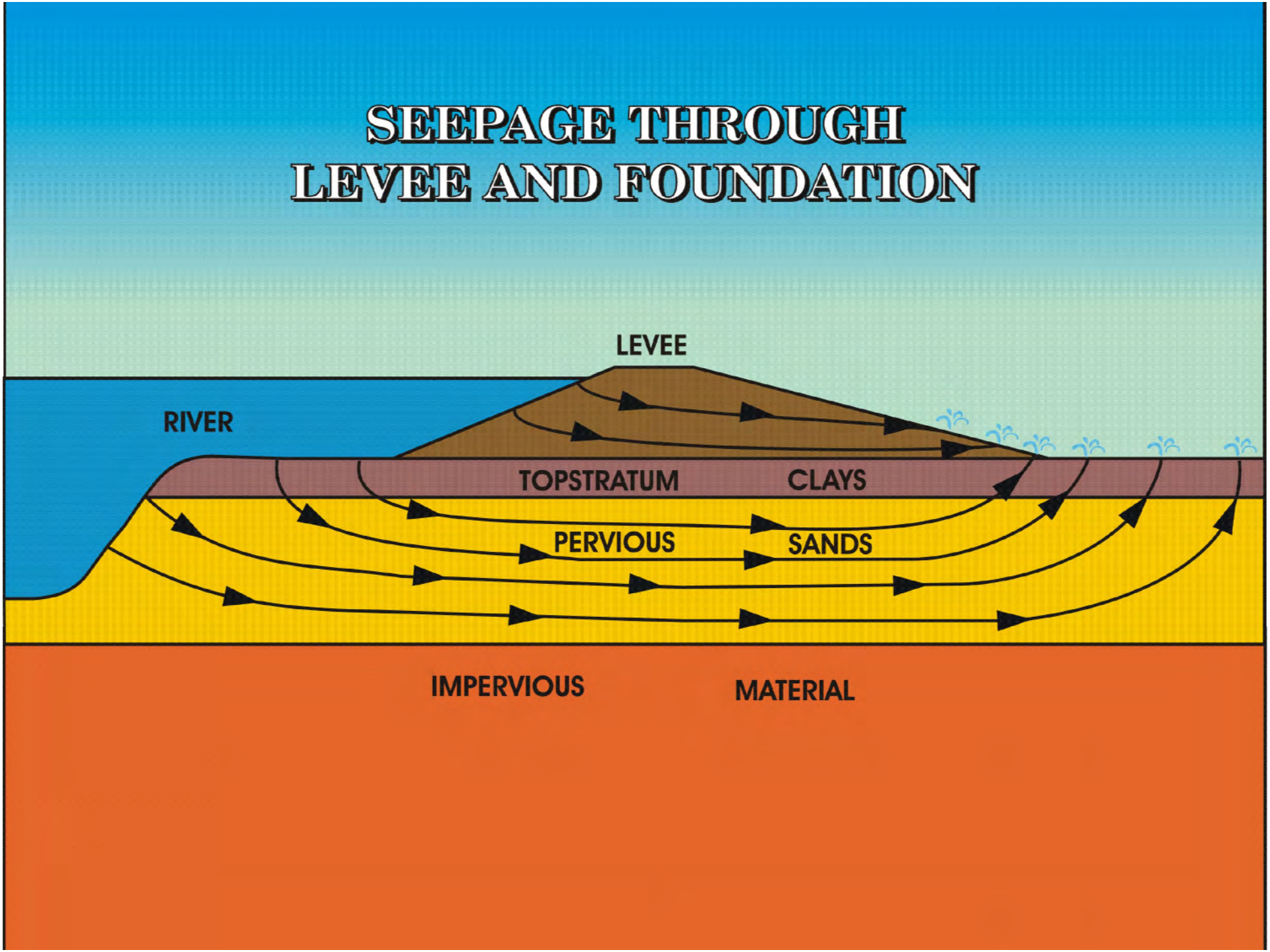
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david.c.serafini@hotmail.com

2005 Infrastructure Conference

A Review of Corps of Engineers Levee Seepage Practices and Proposed Future Changes

George Sills
ERDC Geotechnical & Structures Laboratory
Vicksburg, MS

August 2005


SEEPAGE THROUGH
LEVEE AND FOUNDATION
LEVEE
RIVER
TOPSTRATUM
CLAYS
PERVIOUS
SANDS
IMPERVIOUS
MATERIAL

Darcy's Law

$$Q = kiA$$

Piping

"Piping *cannot* be analyzed by any rational method."

TM 5-818-5

Governing Equations

- Flow can be described by the following equation

$$\frac{\partial}{\partial x}\left(T_{xx}\frac{\partial h}{\partial x}+T_{xy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial y}\left(T_{yx}\frac{\partial h}{\partial x}+T_{yy}\frac{\partial h}{\partial y}\right)=S\frac{\partial h}{\partial t}$$

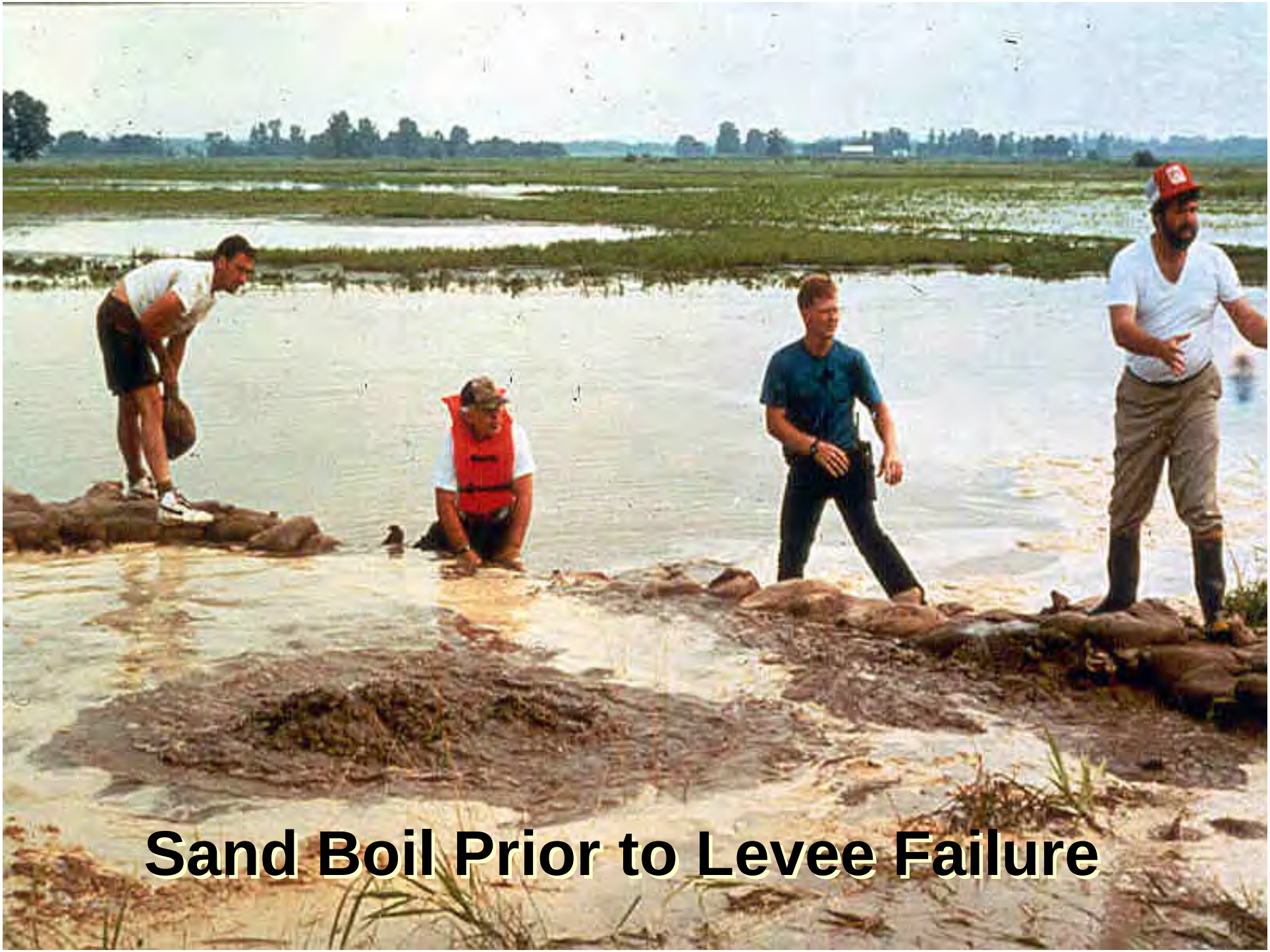
  - where
    - h = head
    - T = transmissivity coefficient
    - S = storage coefficient

Governing Equations

- Transformation of governing equations and simplification by assuming isotropic condition (Txx=Tyy=T) yields

$$S\frac{\partial h}{\partial t} = \frac{T}{J^2}.\left(\alpha h_{\xi\xi} - 2\beta h_{\xi\eta} + \gamma h_{\eta\eta}\right) + \frac{\left[y_\eta T_\xi - y_\xi T_\eta\right].\left[y_\eta h_\xi - y_\xi h_\eta\right] + \left[-x_\eta T_\xi + x_\xi T_\eta\right].\left[-x_\eta h_\xi + x_\xi h_\eta\right]}{J^2}$$


Sand Boil



Sand Boil Prior to Levee Failure


Levee Crevasse

Consequences of Flooding

Sacramento Resources at Risk in a Major Flood

- 400,000 people
- 170,000 structures
- 5,000 businesses
- 1,200 public facilities
- 117 schools
- 40 major roads and highways
- $7-$15 billion in damage in a single flood event



Historic 1861 Sacramento



Flood of 1986

- Largest flood recorded for Sacramento and American Rivers
- Close to 100 year event
- 14 deaths
- $379,000,000 in damages
- American River
  - Design capacity = 115,000 cfs
  - 24 hours at 130,000 cfs
  - Potentially within 3 hours of failing the levees





Flood of 1997

- Close to 100 year event
- 37 levee breaches in levee system
- 8 deaths
- 2,300 homes destroyed
- $524,000,000 in damages
- Seepage and piping predominant mode of failure







Situational Awareness

- Many levee feasibility studies were done before 1997 flood lessons learned
- Hydrology changing
- 1997 flood lessons
- New seepage criteria
- Cost of levee projects



Situational Awareness

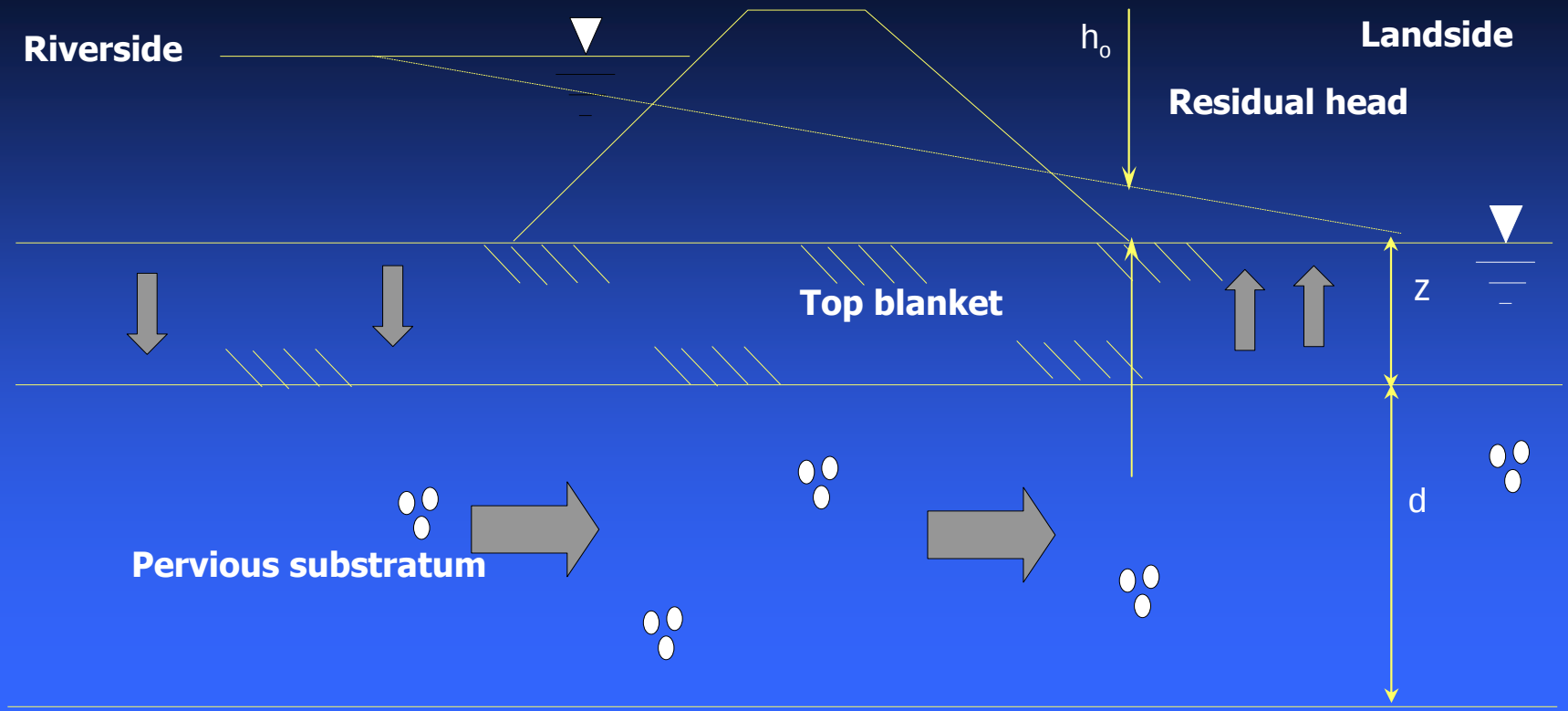
- Many levee feasibility studies were done before 1997 flood lessons learned
- Hydrology changing
- 1997 flood lessons
- New seepage criteria
- Cost of levee projects
- **Need to evaluate CESPK criteria**



Task Force Composition

	George Sills	CEMVK	Lead
SHANNON & WILSON, INC.	Chris Groves	Consultant	Member
	Dr. M. Al-Hussaini	CELRD	Member
	Dr. Les Harder	State of California	Member
	Dr. Tom Wolff	Michigan State	Seamless ITR
	Dr. Mike Duncan	Virginia Tech	ITR

Hydraulic Gradient



$$i_o = \frac{h_o}{z}$$

Major USACE Seepage Documents

- TM 3- 424, dated 1956
- CEMVD “Staff Study,” dated 1962
- EM 1110-2-1913, dated 2000
- ETL 1110-2-555, dated 1997

1962 "Staff Study"

- No berm required if
  - i < 0.5 and no past problems
- If i > 0.8 design berm
  - Designed for i = 0.3 at levee toe
  - i at berm toe = 0.8
  - Berm width 300 to 400 ft.
- Minimum berm if i > 0.5 and < 0.8, 150 ft.

EM 1110-2-1913

- No berm required if
  - i < 0.5 and no past problems
- If i > 0.8 design berm
  - Designed for i = 0.3 at levee toe
  - i at berm toe = 0.8
  - Berm width 300 to 400 ft.
- Minimum berm if i > 0.5 and < 0.8, 150
- Relief wells
  - Designed for i = 0.5 between wells

ETL 1110-2-555

- New levees — NOT existing projects
  - Design berm if i > 0.3 at levee toe
    - Design so that i = 0.3 at levee toe
  - Relief wells
    - Designed for i = 0.5 between wells

Recommendations

- Design to a gradient of 0.5
  - Obtain adequate subsurface information
  - Insure $\gamma sat \geq 110$ lb/ft^3
  - Study past flood histories
  - Plan to maintain
  - Develop a flood fight plan



Can ya teach this dog to hunt something new?

ETL 1110-2-569 (May 2005)

- If i > 0.8 design so i = 0.5 at levee toe for
  - Berms, between relief wells, and landside drainage ditches
- If i > 0.5 and < 0.8 minimum berm is 4 X the levee height
- Thickness of berm increased the calculated/estimated amount for shrinkage and consolidation
- Contains **WARNING** about arbitrary limiting berm width to 300 to 400 ft may not be safe.

Item 450-R Seepage Berm Analysis

			io = 0.3					io = 0.5				
Station	Zt (ft)	ha (0.8*Zt) (ft)	Berm Width Computed (ft)	ho´ (ft)	ha@x = 300´ (ft)	il@x = 300´ (ft)	Safety Factor	Berm Width Computed (ft)	ho´ (ft)	ha@x = 300'(ft)	il@x = 300´ (ft)	Safety Factor
2715+00 B	7	5.6	893	18.8	11.41	1.63	**0.49**	837	18.15	11.02	1.57	**0.51**
2720+00	4	3.2	817	15.13	7.11	1.78	**0.45**	752	14.25	6.70	1.67	**0.48**
2725+00	8	6.4	582	14.4	8.97	1.12	**0.71**	539	13.85	8.63	1.08	**0.74**
2730+00	5	4	654	13.13	6.75	1.35	**0.59**	600	12.43	6.39	1.28	**0.63**
2745+00	12	9.6	480	15.8	11.32	0.94	**0.85**	448	15.42	11.04	0.92	**0.87**
2750+00	10	8	604	16.22	10.98	1.10	**0.73**	561	15.69	10.62	1.06	**0.75**

Item 450-R Seepage Berm Analysis for 100-yr Flood

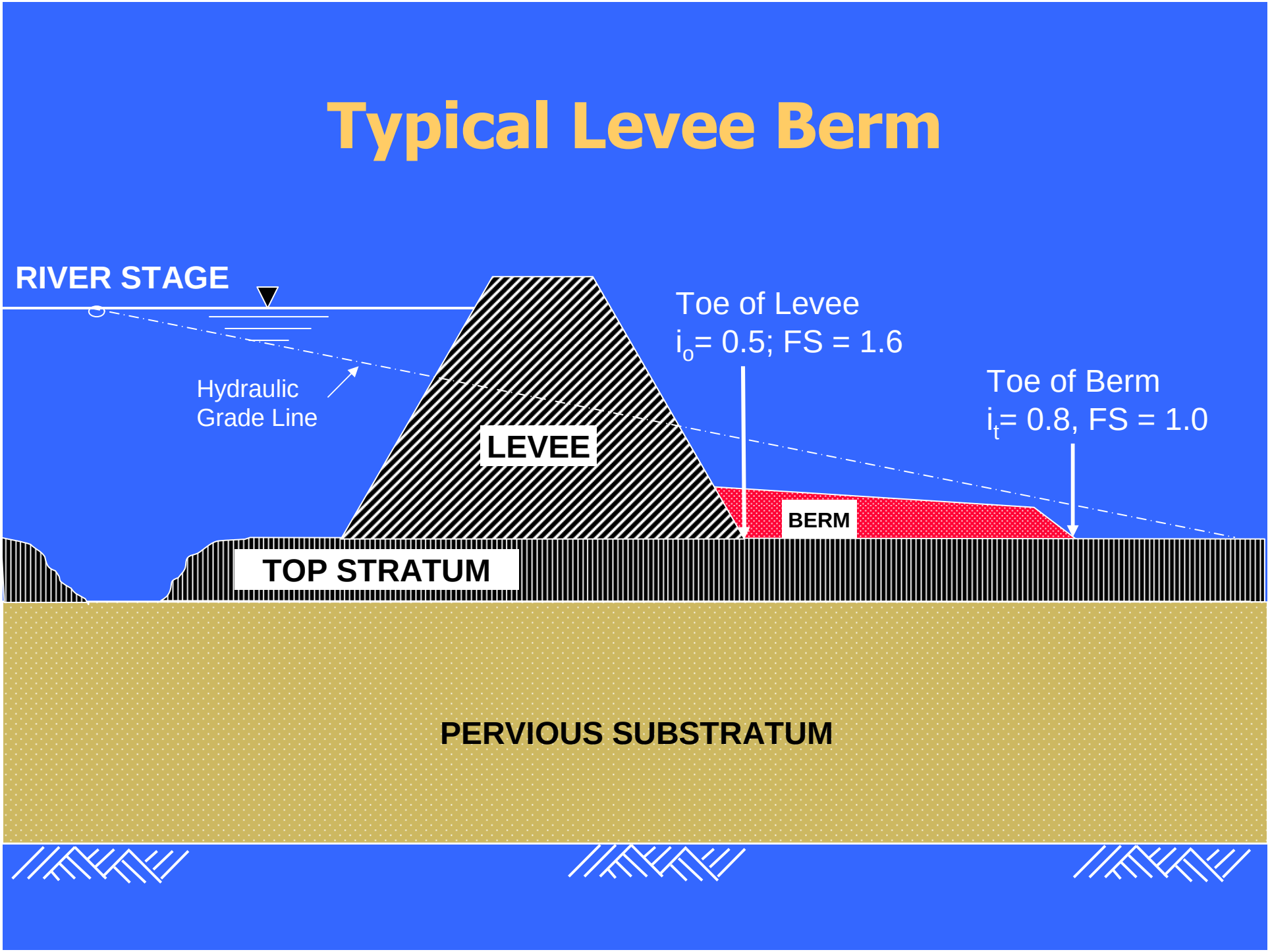
Station	Zt (ft)	t @ Design Flowline	ho ´	io	Safety Factor @ Toe of levee	ha(ft)= ho ´*e^-cx	il	Safety Factor @ Toe of Berm
2715+00 B	7	9.77	13.85	0.24	**3.29**	8.41	1.20	**0.67**
2720+00	4	8.17	10.79	0.22	**3.72**	5.07	1.27	**0.63**
2725+00	8	6.57	8.42	0.13	**6.30**	5.25	0.66	**1.22**
2730+00	5	6.62	9.16	0.22	**3.66**	4.71	0.94	**0.85**
2745+00	12	6.28	11.78	0.30	**2.66**	8.44	0.70	**1.14**
2750+00	10	7.13	12.06	0.29	**2.78**	8.16	0.82	**0.98**

Note: io = 0.5 at levee toe for design flowline

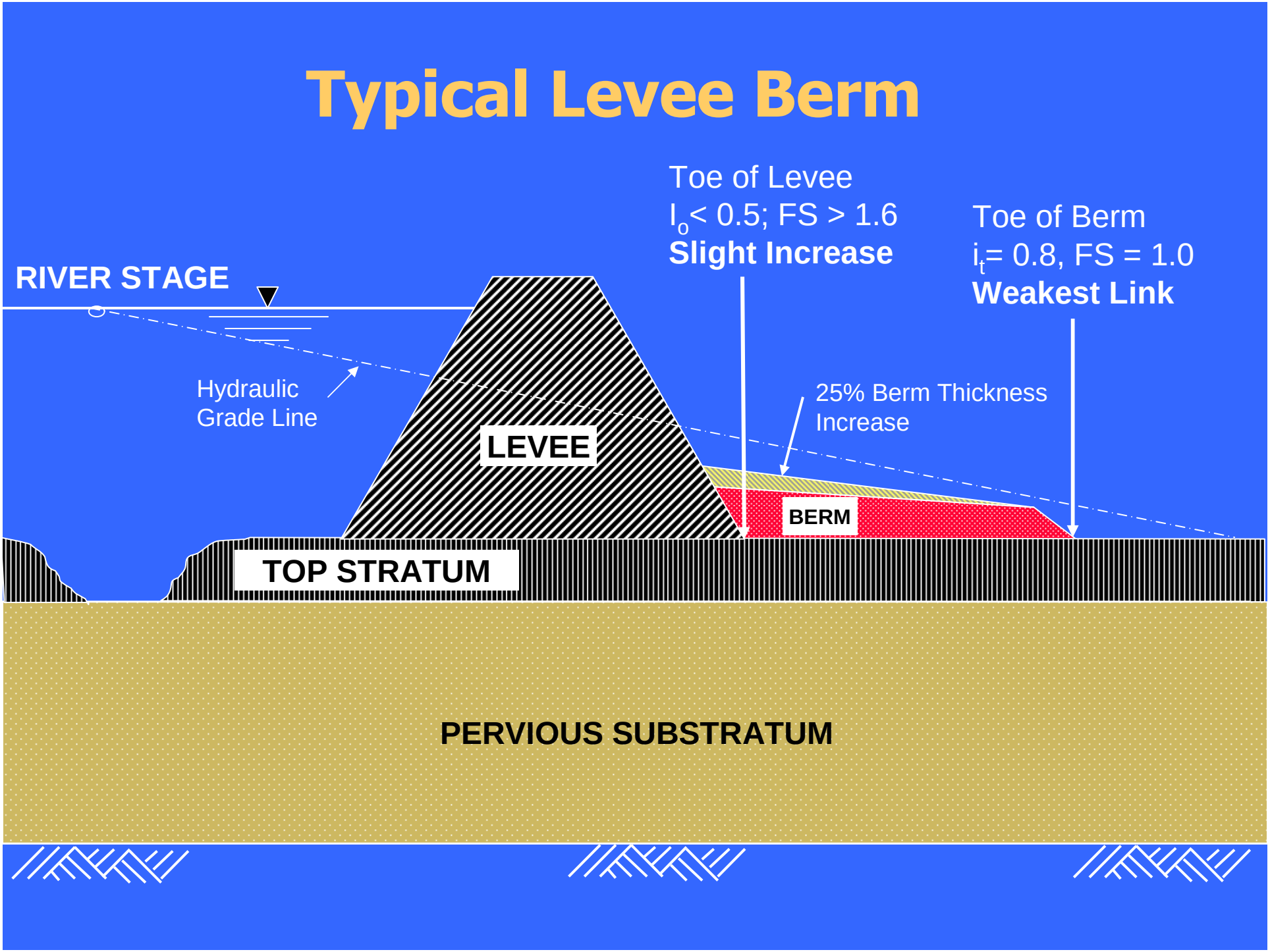
MRL Item 450-R

Berm Embankment Savings	315,000 cu yds	Cost Savings	$ 693,000
Right-of-Way Savings (from borrow area)	30 acres	Cost Savings	$ 30,000
		Total Savings	$ 723,000

Typical Levee Berm



Typical Levee Berm







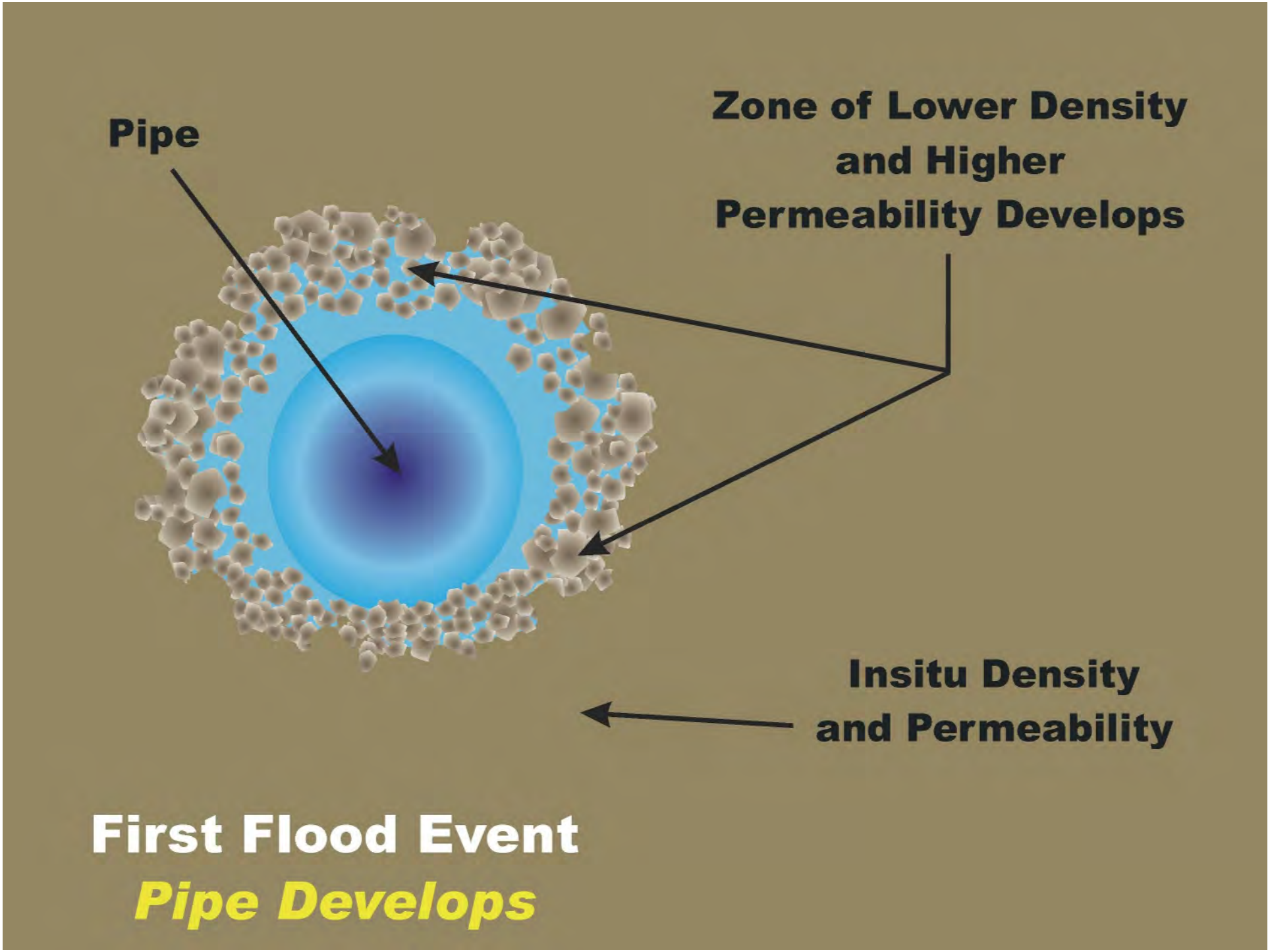


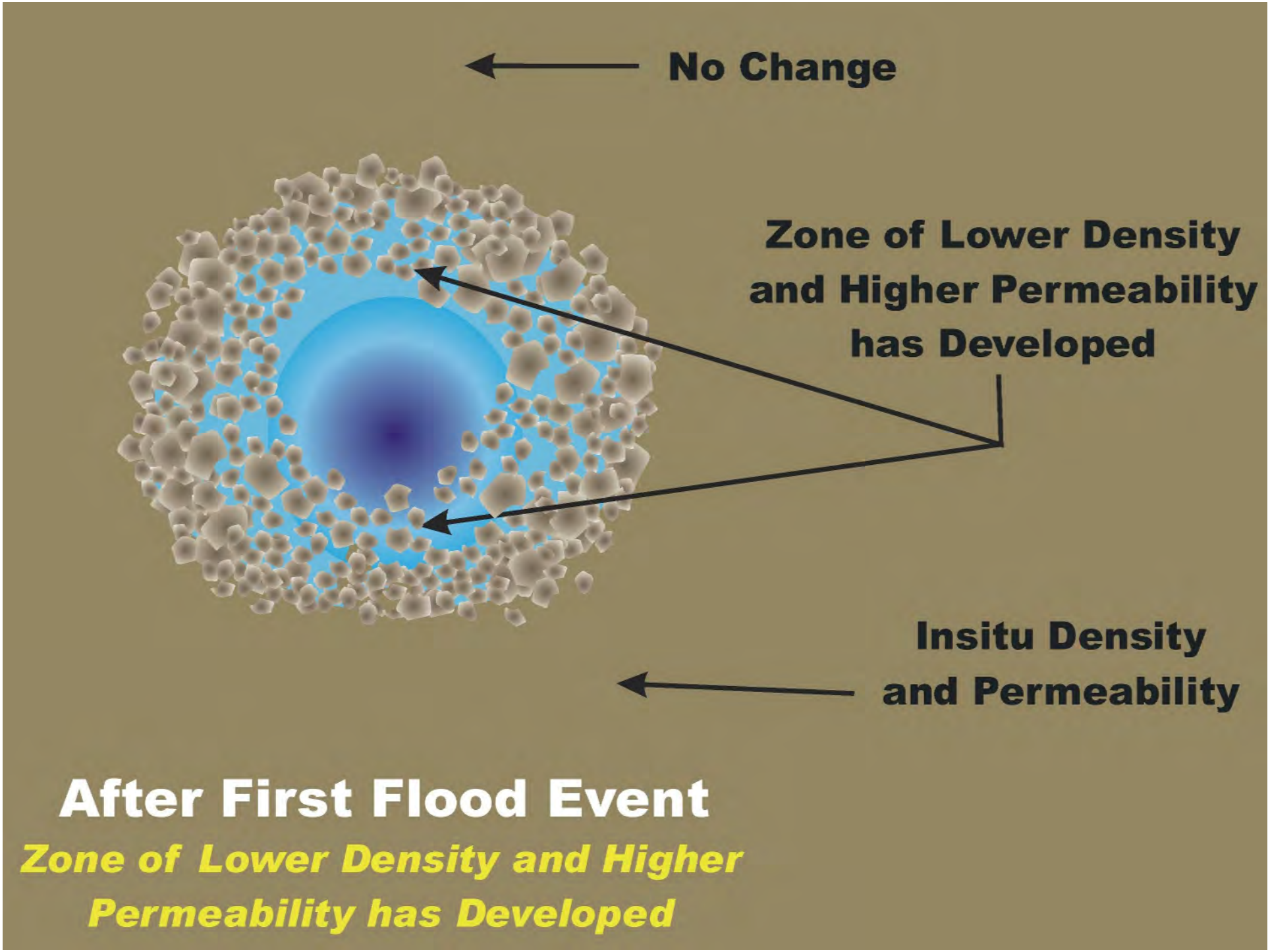


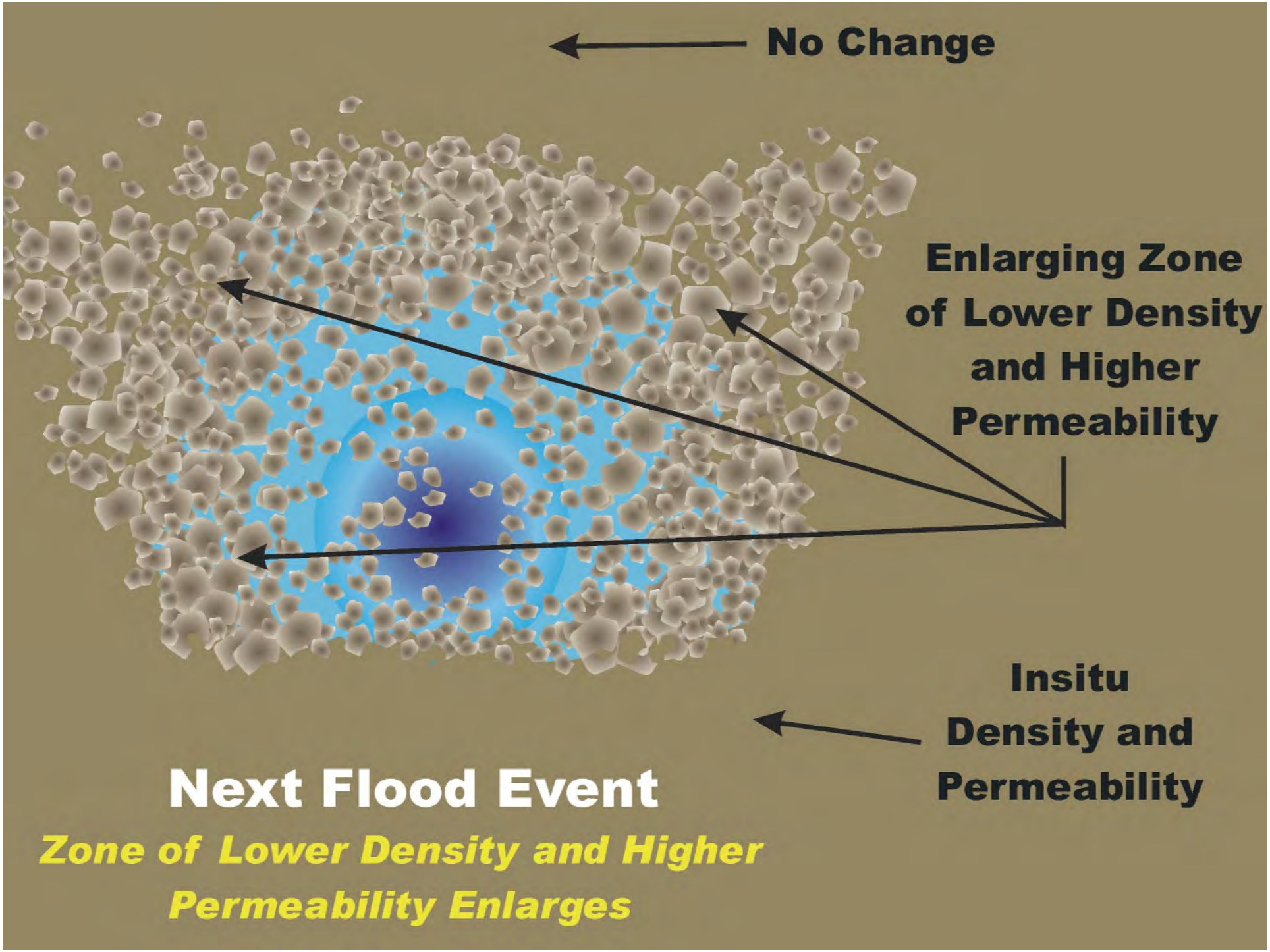


Factors Influencing Permeability

- Particle size and shape
- Properties of the fluid
- Hydraulic gradient
- Degree of saturation
- DENSITY


Pipe
Zone of Lower Density
and Higher
Permeability Develops
Insitu Density
and Permeability
First Flood Event
Pipe Develops


No Change
Zone of Lower Density
and Higher Permeability
has Developed
Insitu Density
and Permeability
After First Flood Event
Zone of Lower Density and Higher
Permeability has Developed

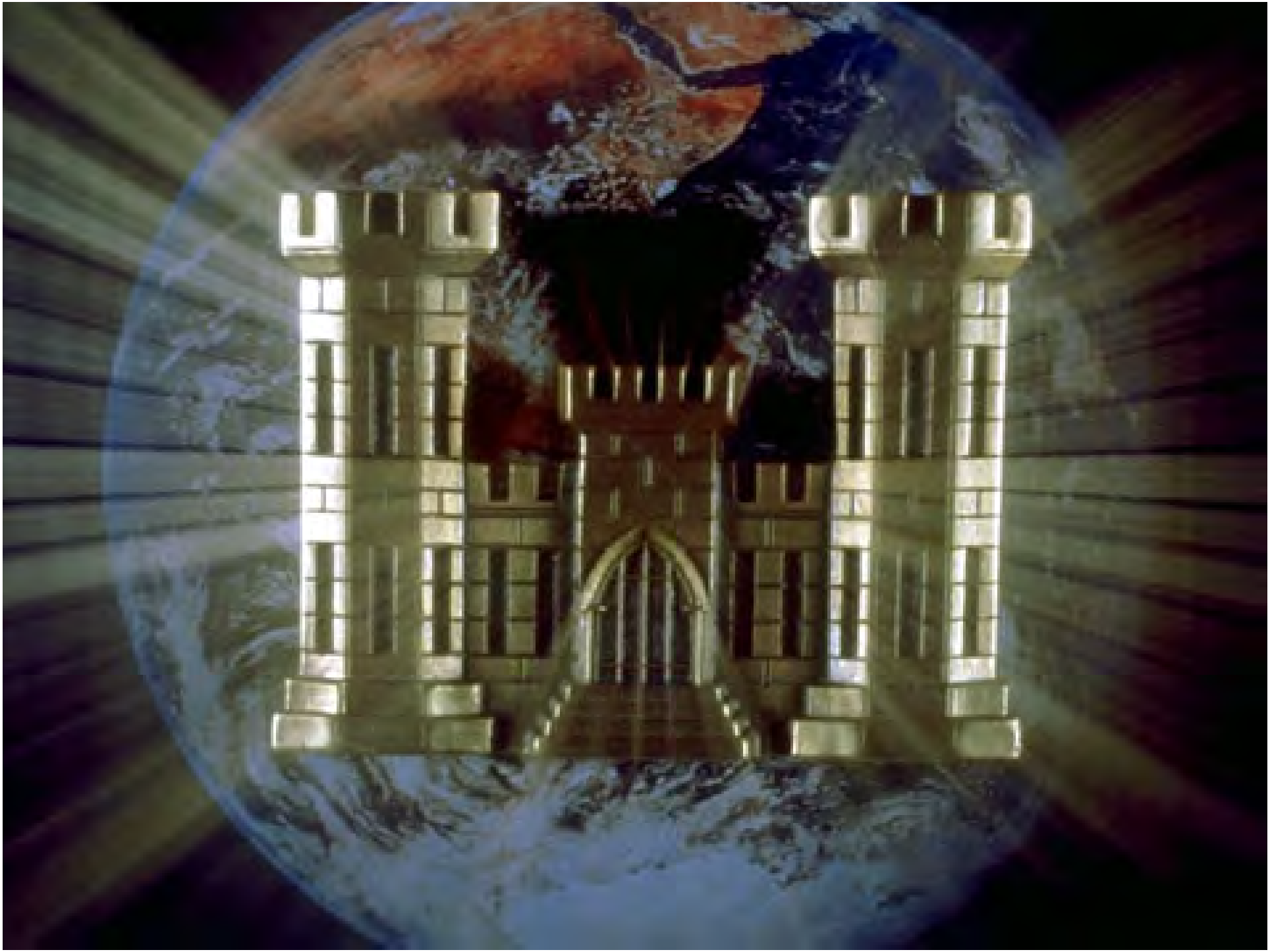

No Change
Enlarging Zone of Lower Density and Higher Permeability
Insitu Density and Permeability
Next Flood Event
Zone of Lower Density and Higher Permeability Enlarges

Research Goals

- Develop empirical basis for piping occurrence
- Develop theoretical basis for piping occurrence
- Develop predictive tool
- Develop monitoring tool

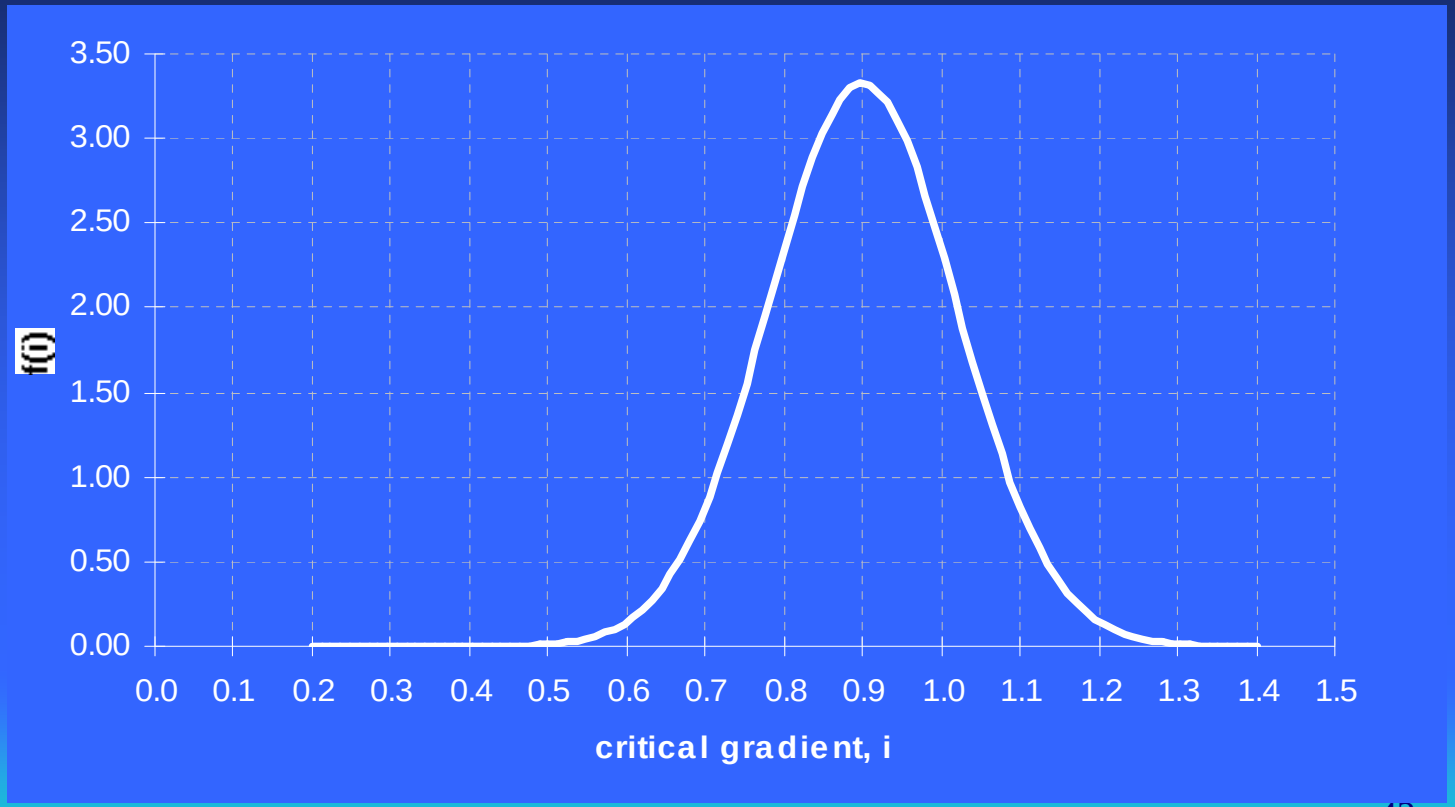
Conclusions (Needs)

- Mathematical model to predict behavior
- Identify reaches that have been affected
- Develop economical methods of repair
- EM 1110-2-1913 (Rewritten)



Probabilistic Analysis in Task Group Report

- Critical Gradient **N(0.9, 0.12)**



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Historical Changes in the State of the Art of Seismic Engineering and Effects of those changes on the Seismic Response Studies of Large Embankment Dams

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Seismic Safety Evaluation Process for Embankment Dams and Foundations

Authority, Guidance & Procedures

ER 1110 – 2 – 1155 (Sept 1997)

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Seismic safety evaluations of embankment dams is typically a complex, multistage process requiring progressively more detailed definition of certain project characteristics and analyses at each subsequent phase.

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- **Seismic evaluations / re-evaluations are to be accurately identified and conducted with minimum expenditures of project funds.**

- **Embankment dams and foundations not requiring modifications are accurately identified and removed from study at the earliest possible point in the evaluation process**

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Seismic Evaluations of USACE dams are funded through operations and maintenance funds.

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Seismic Evaluation Procedures and Methods of Analysis

- Develop design earthquake, and resulting ground motion parameters, response spectra and earthquake time histories at the site.
- Perform field investigations.
- Determine the liquefaction resistance of the embankment and foundation.
- Determine post earthquake shear strength of soils.
- Prepare cross-sections of areas of the dam with highest potential for instability due to existence of liquefaction susceptible soils.
- Perform seismic response analyses of these sections to determine the expected dam performance.
  - Static Equilibrium Slope Stability
  - Deformation Response Analyses

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- **Liquefaction Susceptibility of Embankment and Foundation Soils**

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Liquefaction Susceptibility

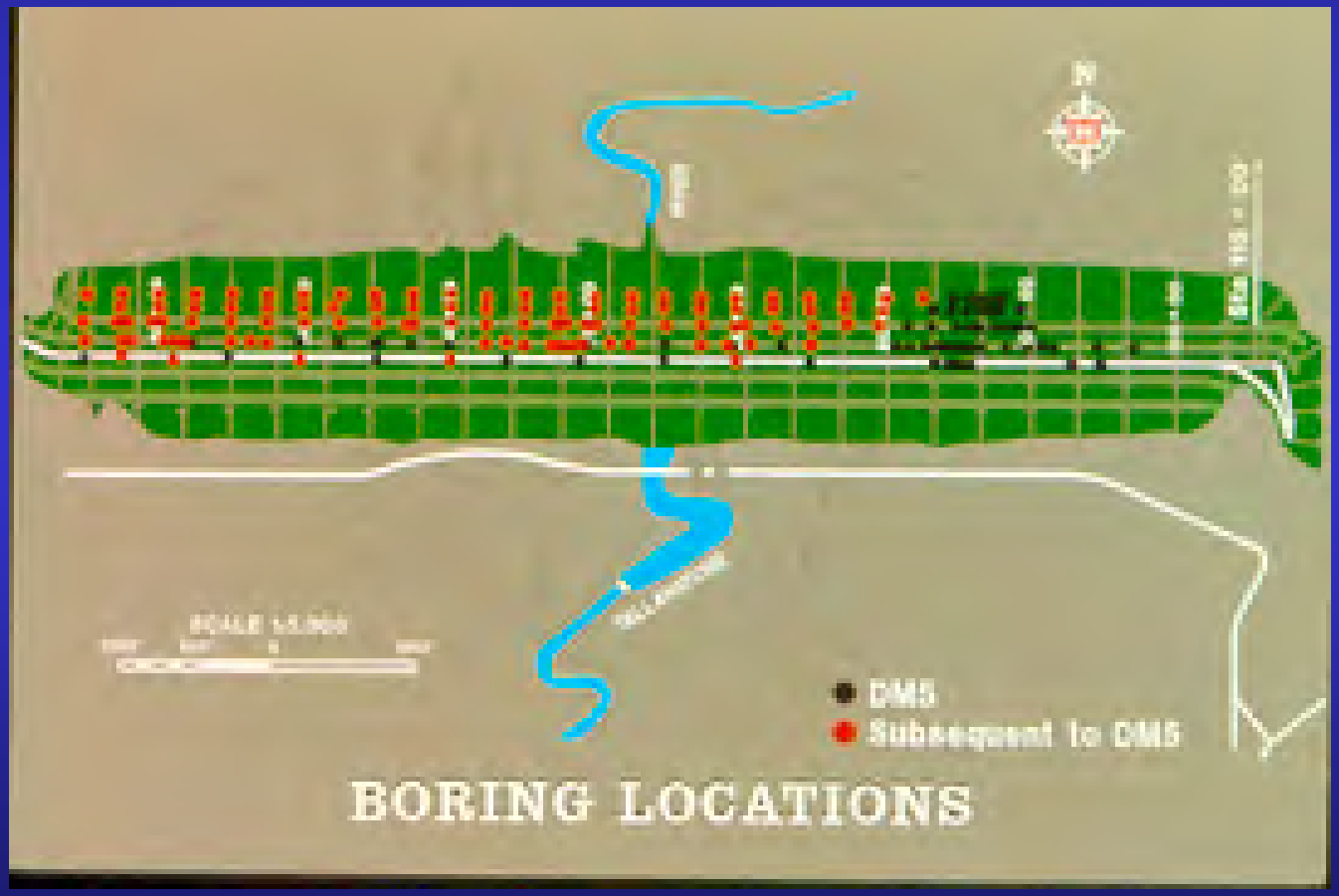
- Seed's SPT Based Empirical Approach
- Chinese Criteria

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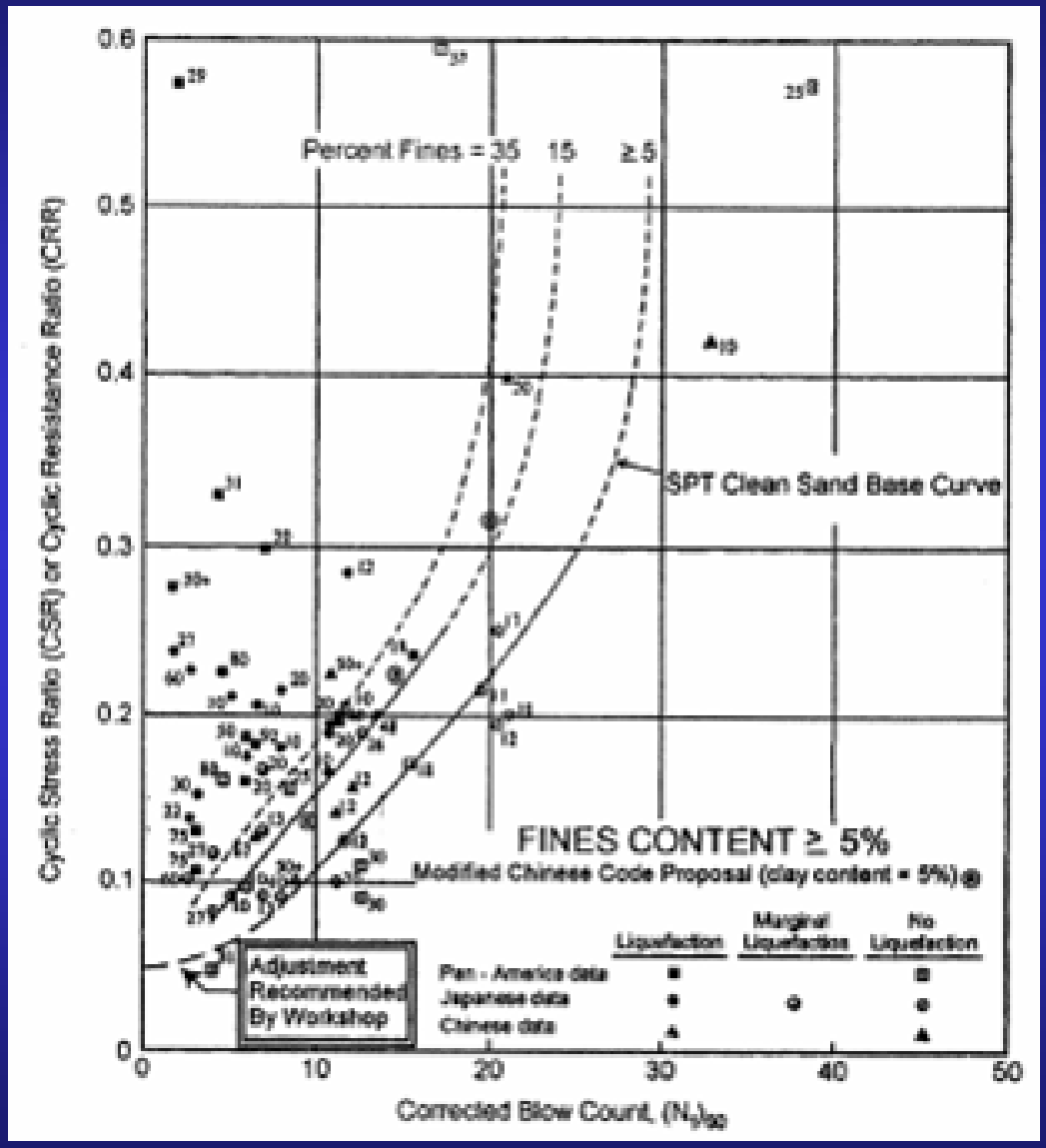
CHINESE CRITERIA for Liquefaction of Fine-Grained Soils

- Liquid Limit (L_L) $\leq$ 35
- Natural Water Content (W_N) $\geq$ 0.90 L_L
- % Passing 0.005mm $\leq$ 20

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Liquefaction Susceptibility Criteria
Sardis Dam Earthquake Study

Sands $N_{1(60)} \leq 10$

Fine Grained Soils: $N_{1(60)} \leq 4$

$4 \leq N_{1(60)} \leq 10$

and

Chinese Criteria

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Post Earthquake Residual Strength of Liquefiable Fine Grained Soils

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Assumption

Liquefiable fine grained soils perform like remolded soils such that their post earthquake strength is the residual strength of the soil

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Laboratory Testing

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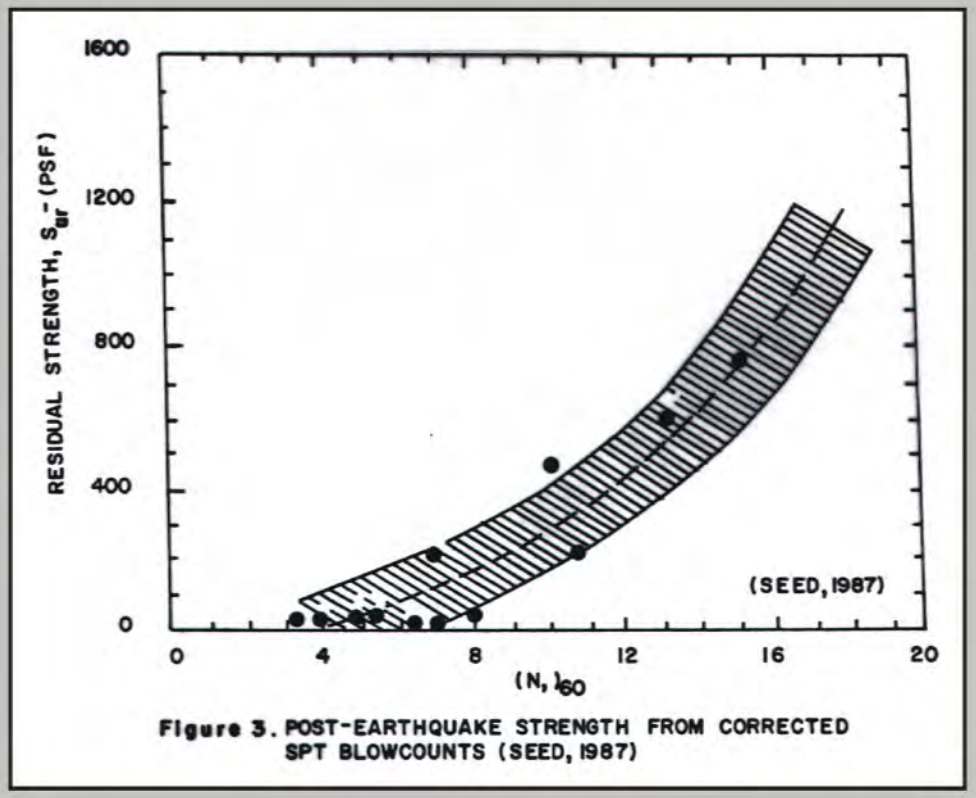
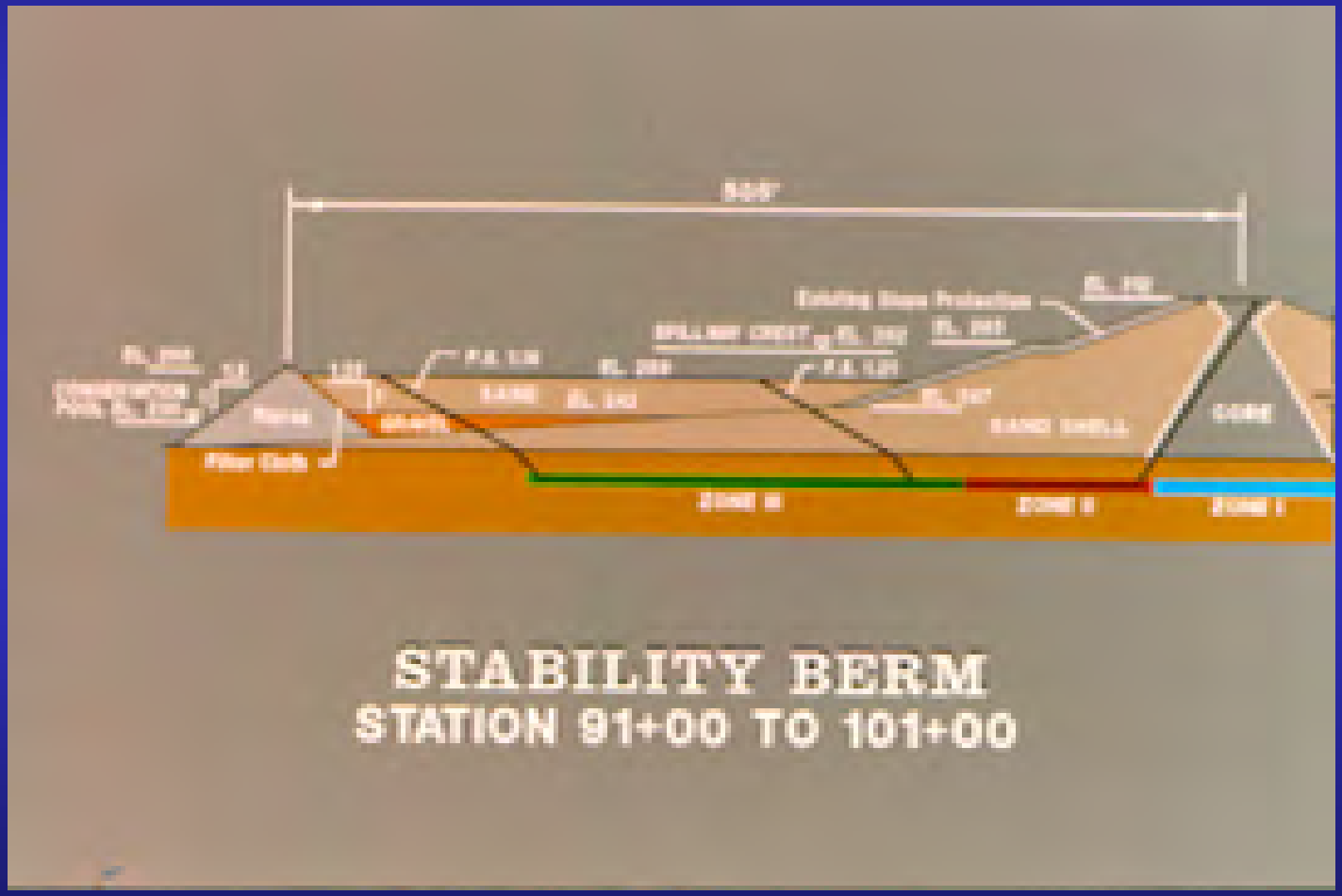


Figure 3. POST-EARTHQUAKE STRENGTH FROM CORRECTED SPT BLOWCOUNTS (SEED, 1987)

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Modification to the Index Properties due to differences in Testing Methods between China and the U. S. and human error between laboratories.

- **Chinese – Fall Cone Device**
- **U. S. A. – Casagrande Device**

Joe Koester (1988)

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1st Recommendation

+ 15 percent to the measured % passing .005 mm

+ 5 percent to the L_L

+ 3 percent to the W_N

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2nd Recommendation

USACE – Vicksburg & Woodward Clyde Consultants

+ 5 percent to the measured % passing .005 mm

+ 2 percent to the L_L

+ 1 percent to the W_N

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Post Earthquake Residual Strength of Liquefiable Fine Grained Soils

Cone Penetration Testing Correlated to the Results of Field Vane Shear Test (FVST)

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$$Su = \frac{Qc - P'}{N_K}$$

$$N_K = \frac{Qc - P'}{Su\ (FVST)}$$

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Sardis Dam E. Q. S.

$N_K = 15$

$S = 4$

Arkabutla Dam E. Q. S.

$N_K = 18$

$S = 4.5$

Enid Dam E. Q. S.

$N_K = 20$

$S = 3.5$

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Liquefaction Susceptibility
Cone Penetration Test Criteria

Sardis Dam E. Q. S

$Qc \leq 20$ tsf

$R_F \leq 2.0$

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Post Earthquake Residual Strength Ratio (Sr/p′)

(Sr/p′) ranges from .07 to .28

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Post Earthquake Residual Strength as a Function of Overburden Stress

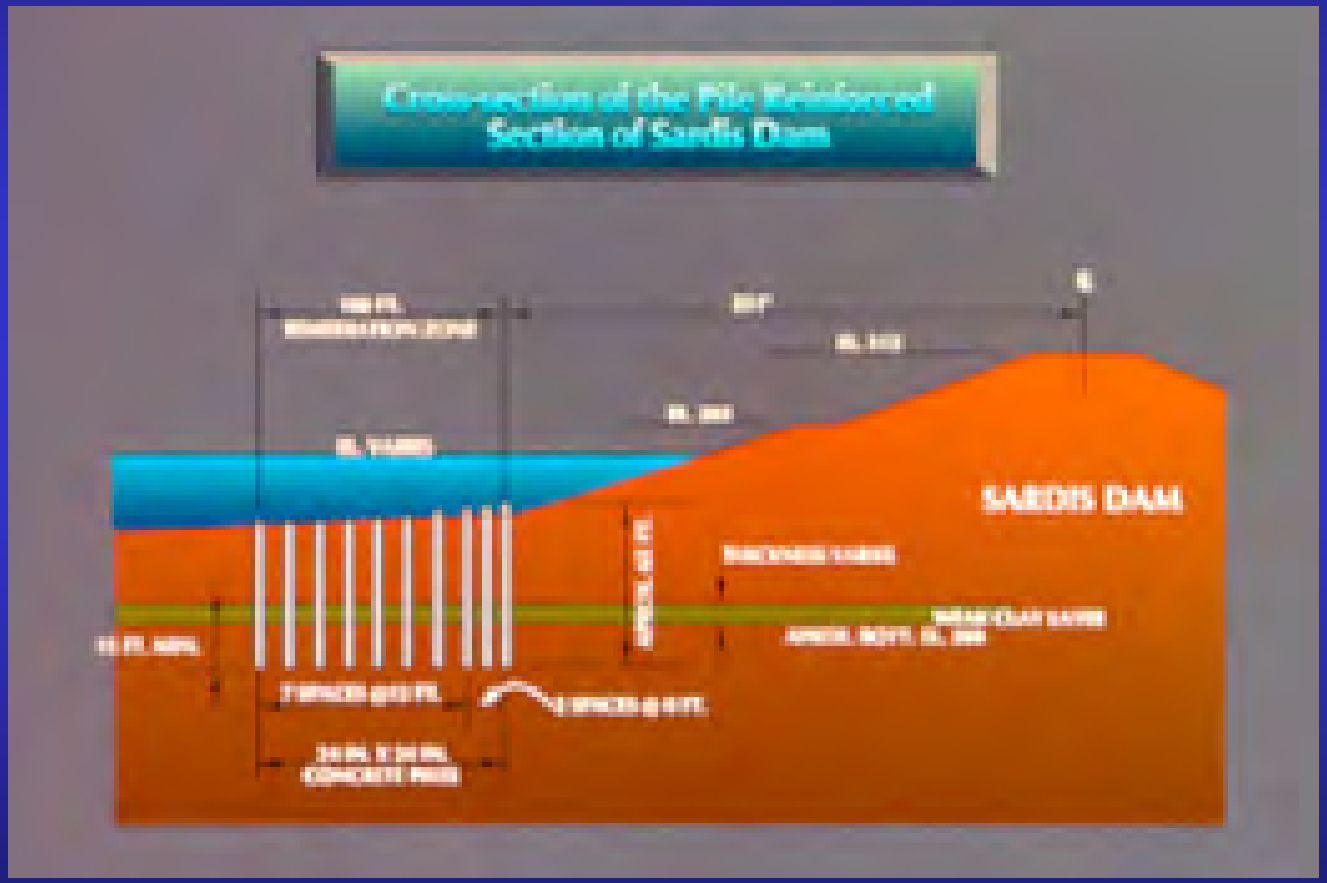
Residual Strength Ratio (Sr/p′)

Sardis Sr/p′ = .075

Arkabutla Sr/p′ = .13 at toe and in the free field

Sr/p′ = .10 beneath embankment

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Liquefaction Susceptibility
Cone Penetration Test Criteria

Arkabutla Dam E. Q. S

Beneath Embankment

$Qc \leq 20$ tsf

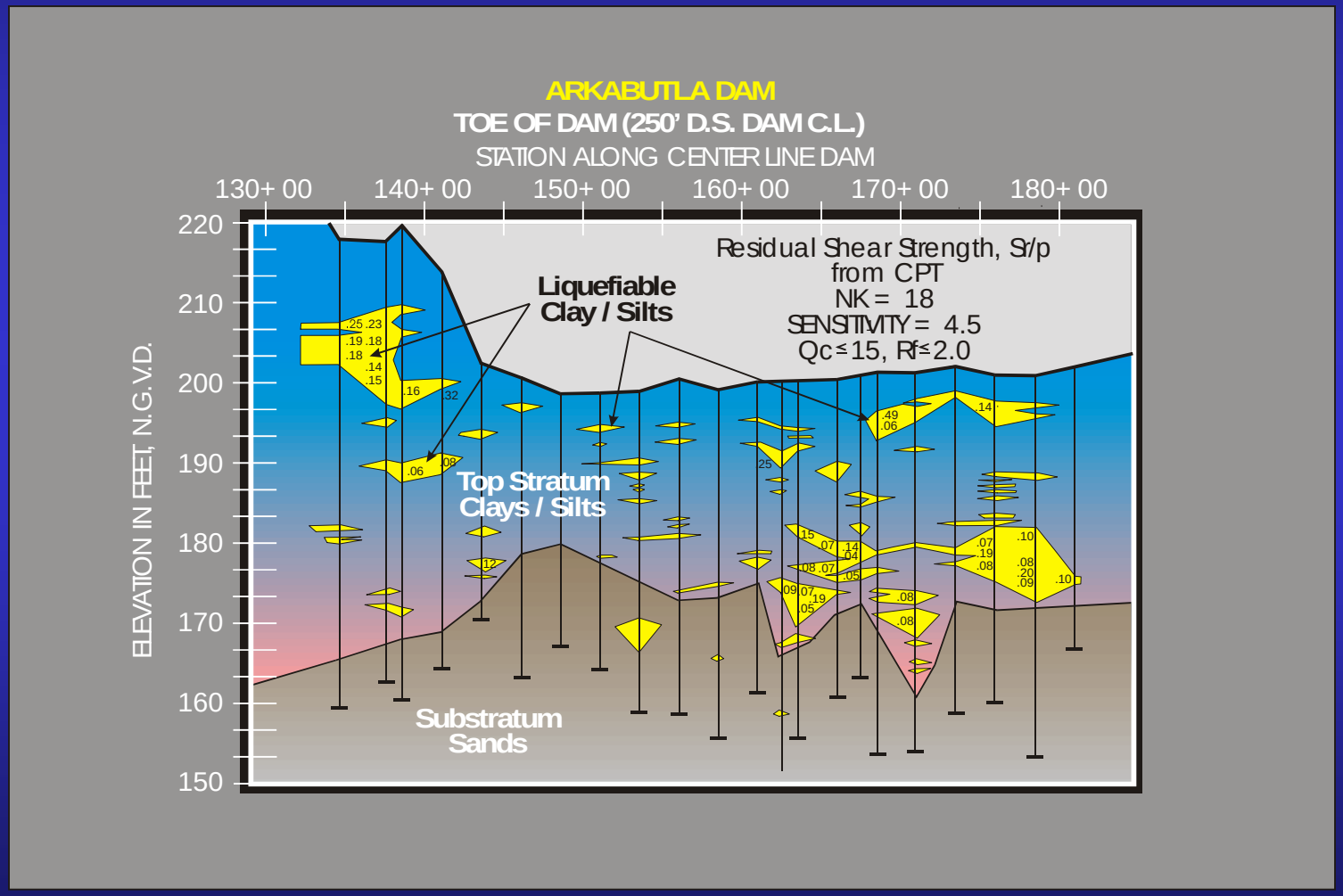
$R_F \leq 2.0$

Toe and Free Field of Dam

$Qc \leq 15$ tsf

$R_F \leq 2.0$

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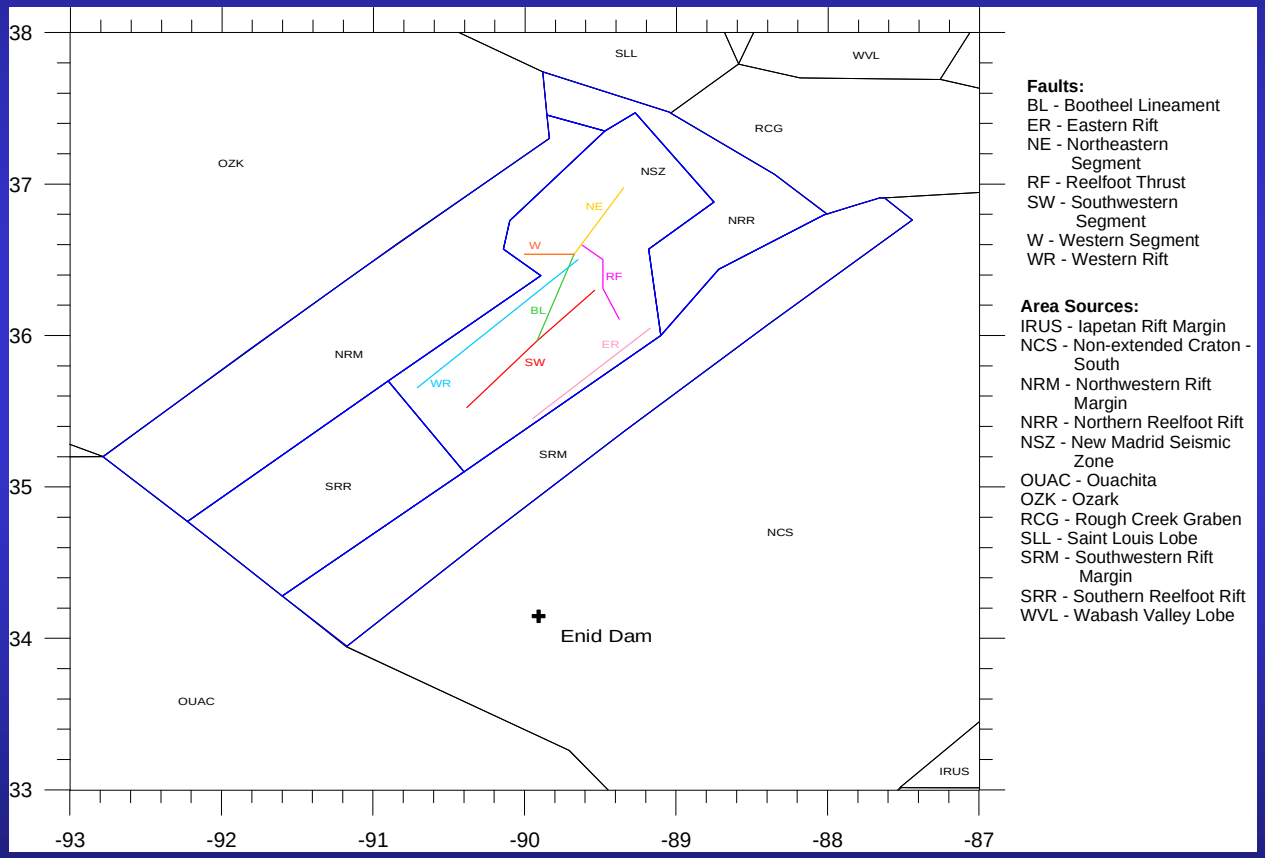
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Enid Dam Earthquake Study

- New evaluation of the Design Earthquake, and resulting ground motions, response spectra, and time histories.

- Modified Chinese criteria for liquefaction Susceptibility.

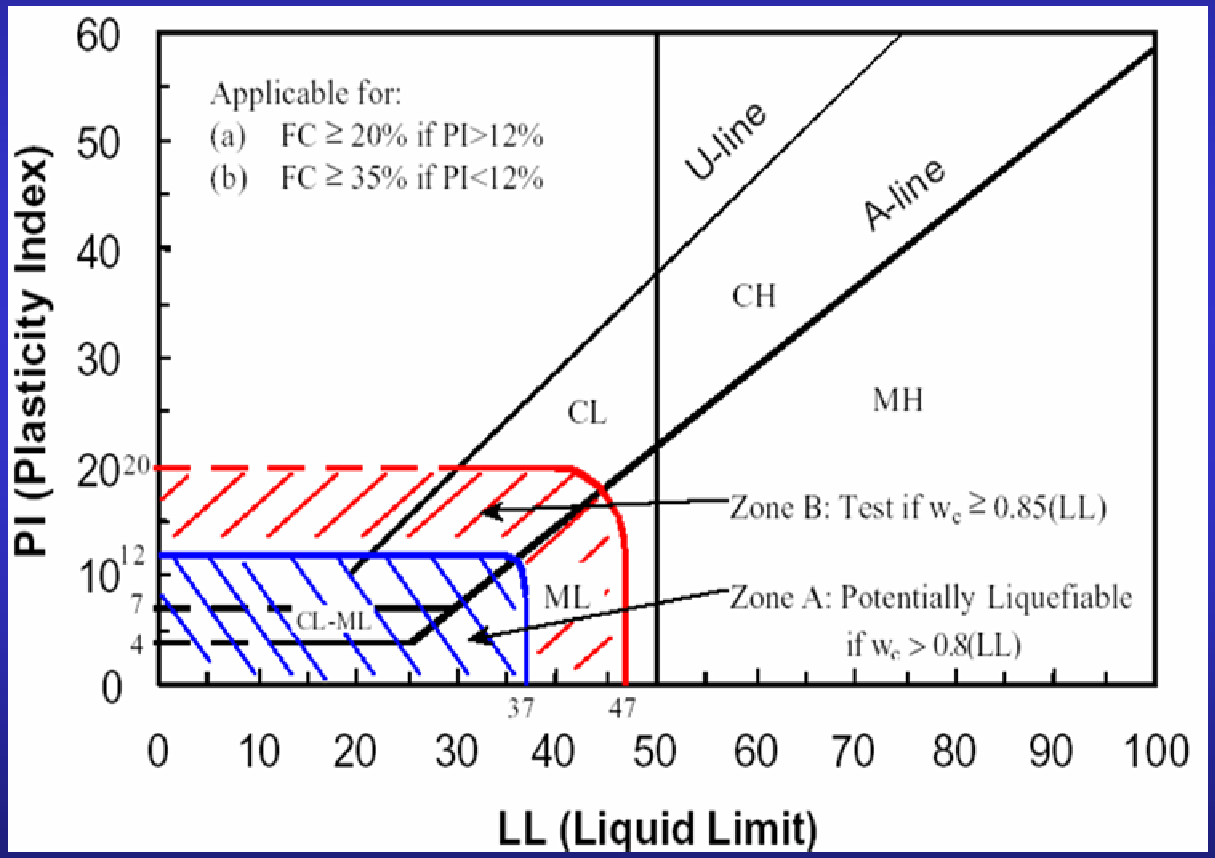
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Faults:
BL - Bootheel Lineament
ER - Eastern Rift
NE - Northeastern Segment
RF - Reelfoot Thrust
SW - Southwestern Segment
W - Western Segment
WR - Western Rift

Area Sources:
IRUS - Iapetan Rift Margin
NCS - Non-extended Craton - South
NRM - Northwestern Rift Margin
NRR - Northern Reelfoot Rift
NSZ - New Madrid Seismic Zone
OUAC - Ouachita
OZK - Ozark
RCG - Rough Creek Graben
SLL - Saint Louis Lobe
SRM - Southwestern Rift Margin
SRR - Southern Reelfoot Rift
WVL - Wabash Valley Lobe

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Lower of the level of uncertainty and conservatism

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SAM STACY
601-631-5635
USACE – Vicksburg

sam.t.stacy@mvk02.usace.army.mil

SECTION 227

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES SEABROOK, NEW HAMPSHIRE

Siamac Vaghar, PE

Geotechnical Engineer

and

Francis Fung, PE

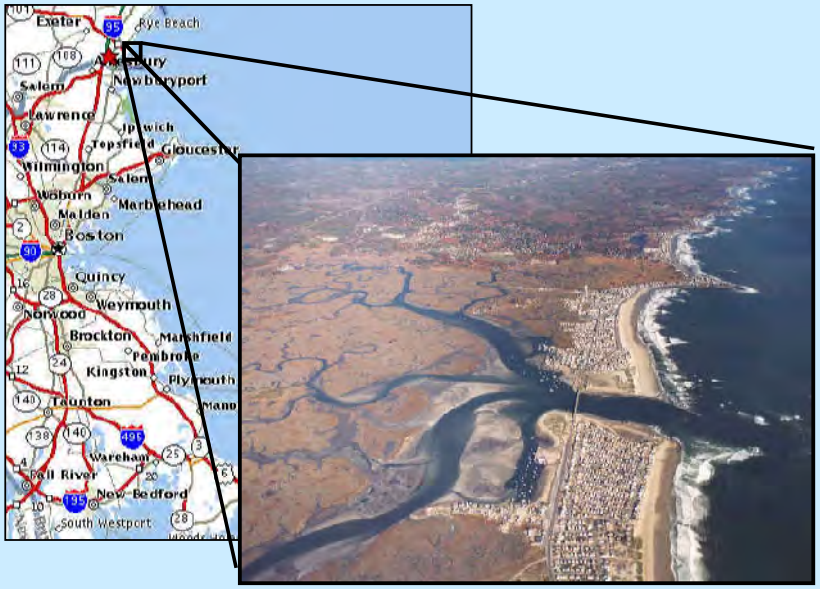
Structural Engineer

US Army Corps of Engineers, Concord, Massachusetts

Authority: Section 227 of the Water Resources and Development Act of 1996 (WRDA 96); Administered by ERDC

- **Research & Development: Advance the state of the art of coastal erosion control technology**
- **Encourage and achieve the development of innovative solutions to the erosion control challenge**
- **Communicate findings to the public, state, and local coastal managers**

Hampton-Seabrook Harbor, adjacent to the mouth of the Blackwater River, located in coastal New Hampshire, USA



DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227



DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227

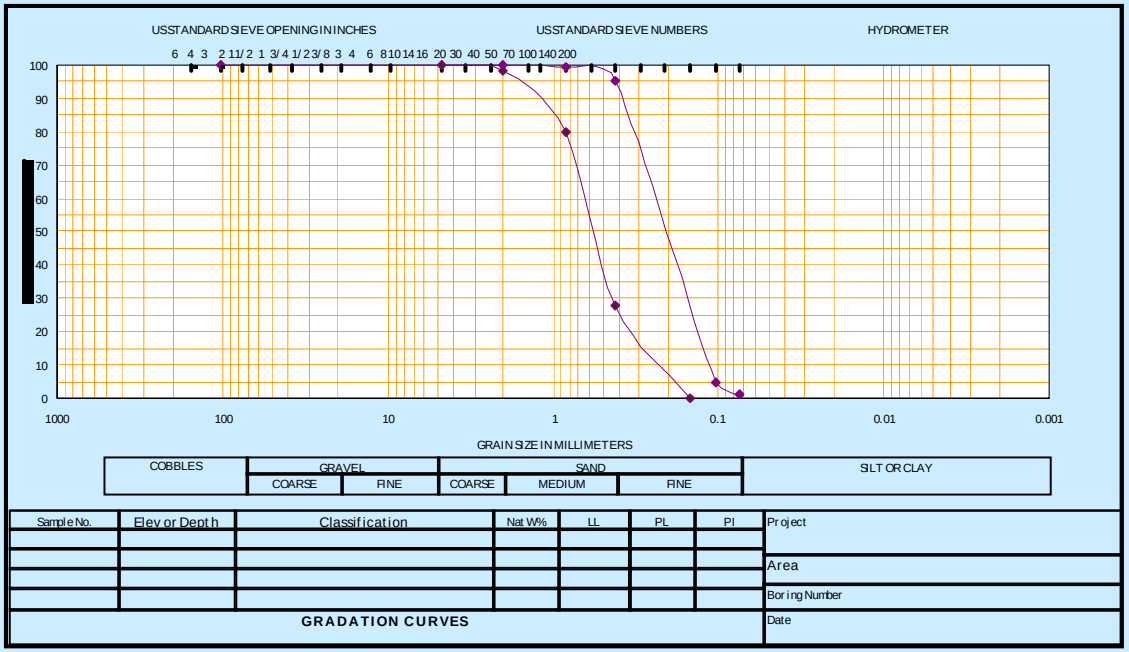
- **Objectives:**
  - **Replace lost intertidal sands**
  - **Reduce sand migration into the Harbor**
  - **Prevent shoreline erosion**
- **Constraints**
  - **Innovative Components**
  - **Ability to remove**
  - **Dredging window of time, November through March**
  - **Cost**
  - **50-year design life**
- **Solutions:**
  - **Install cofferdams across the eroded channel using synthetic sheeting**
  - **Dredge sand from the shoaled areas of the River to encourage flow**
  - **Use the dredged sand to fill between the cofferdams to restore the sand flats**



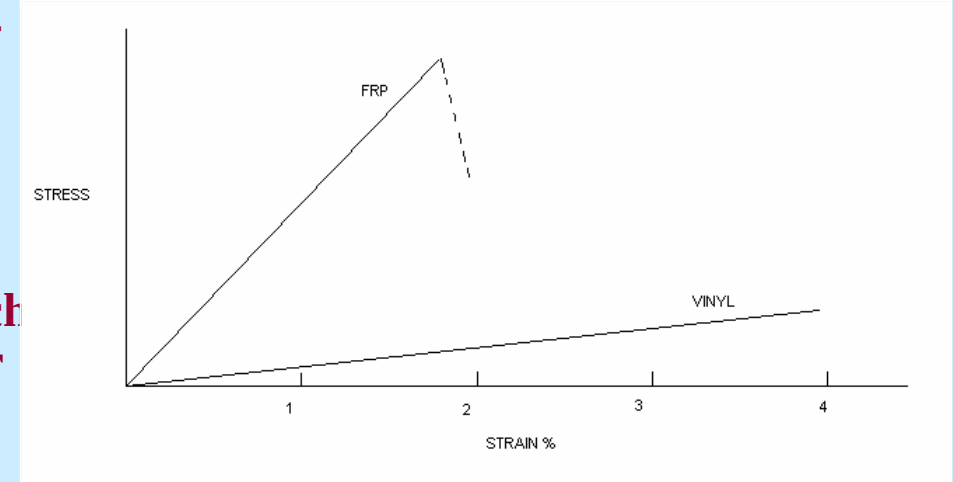
DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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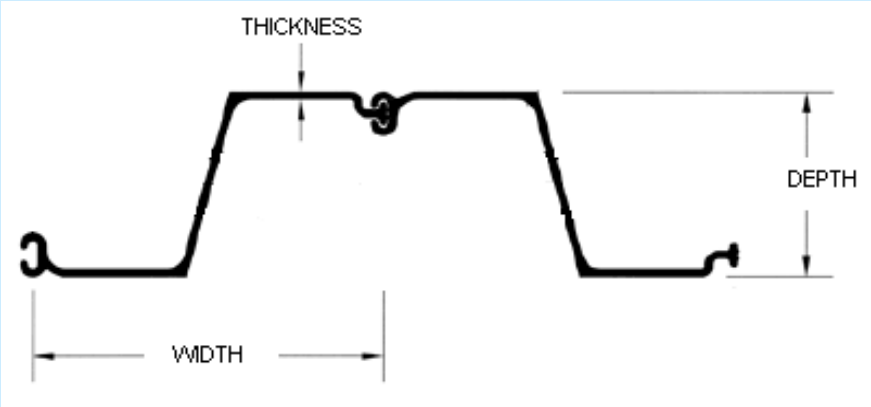
- **Subsurface Conditions**
  - **Medium dense fine sand**
  - **Field SPT = 20**
  - **No obstructions**



- **Synthetic Sheeting**
  - **Vinyl: Made of virgin or recycled plastic or combination (recycled, with virgin veneer)**
    - **High tensile strength**
    - **Less brittle**
    - **10+ years of case histories of use**
  - **Fiber Reinforced Polymer (Fiberglass) Glass fibers embedded in resin matrix such as polyester, polyurethane, or vinyl ester.**
    - **High flexural strength**
    - **More brittle**
    - **Limited number of projects**

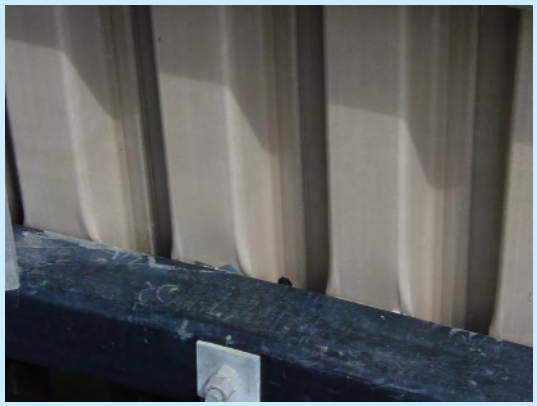


		Vinyl	FRP	
Property	**Test Method**		**Longitudinal***	**Transverse***
Tensile Strength (psi)	**ASTM D638**	6,300	60,000	10,000
Tensile Modulus (psi)	**ASTM D790**	380,000	4,000,000	1,000,000
Width (inch)		18	18	
Depth (inch)		12	8	
Thickness (inch)		0.65	0.25	
Weight (lbs/sf)		8	4	



Note: Longitudinal (along) and Transverse (across) refer to fiber direction.

- **Design Considerations**
  - **Inadequate shear strength or section depth**
  - **Lack of interlock strength**
  - **Limitation on cantilevered length: recent failures during construction**
  - **Longevity: UV resistance, cold**
  - **Lack of standardized tests, data and guide specifications**
  - **USACE Engineering & Construction Bulletin, 2002-31 October 2002:**



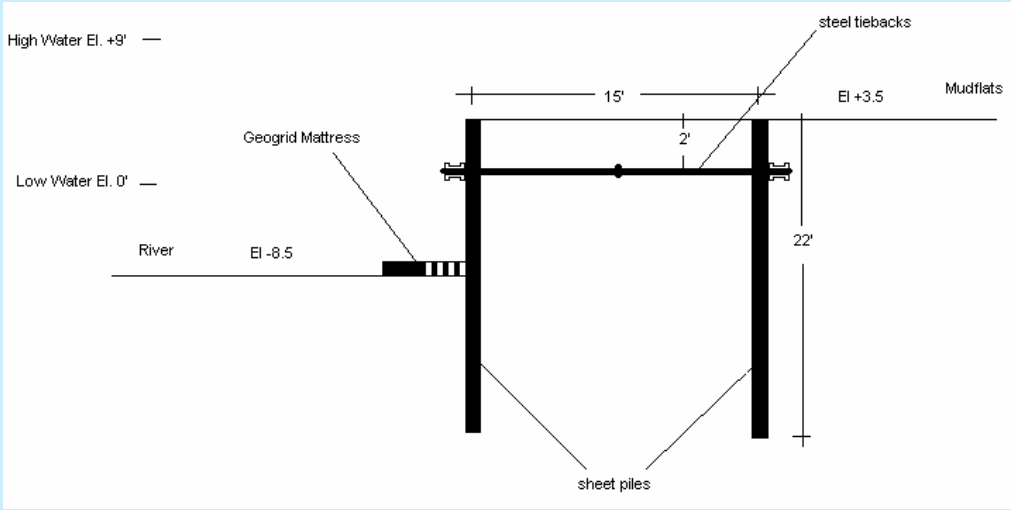


for use. In the meantime, vinyl sheet piling should not be used in applications where life safety and widespread property damage are at stake in the event of failure.

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227

- **Selected Design for each of the two bulkhead**
  - **Double rows of sheets, FRP or heavy vinyl: No cantilever**
  - **Galvanized steel tiebacks and waler: Reliability**
  - **Single Waler: No diving (winter)**
  - **Scour protection: Protect toe**
  - **Drain holes: Reduce loads**

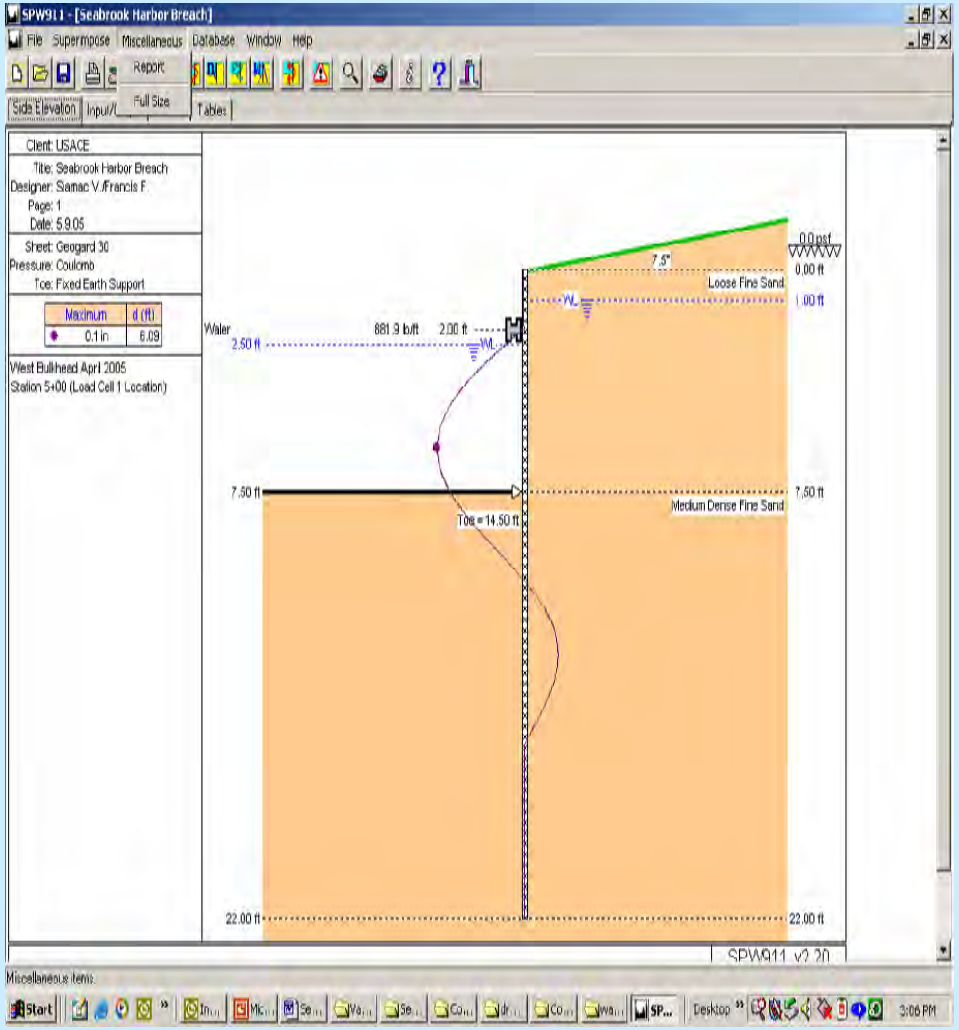


DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

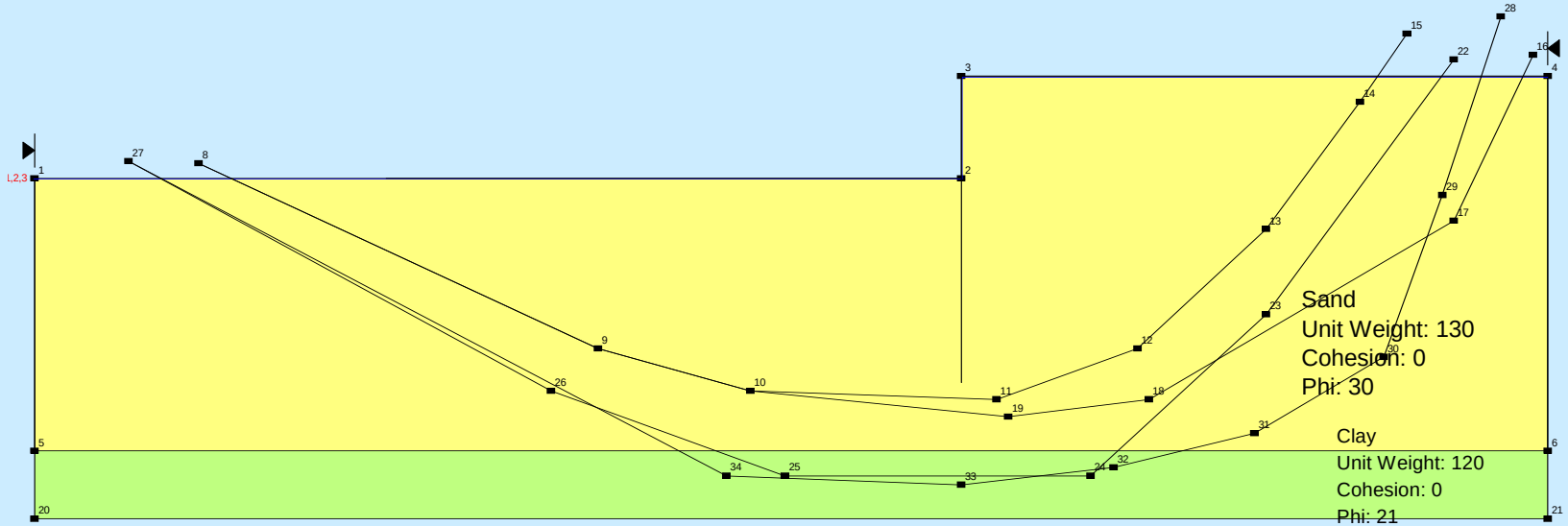
SECTION 227

Design Parameters

- 50-year low tide
- 50% drainage in fill
- 12’ depth to mudline (22 feet sheet length)
- 2 tons horizontal load per linear foot
- Tiebacks 6’ spacing
- 200 psf surcharge



Seabrook Harbor
Slope Stability Analysis
Analysis Method: Bishop (with Ordinary & Janbu)
Slip Surface Option: Fully Specified



- **Component Details**
  - **Waler: 2 x 10” galvanized steel Channels on the outside**
  - **Tiebacks: 18’ long, 2.25” galvanized steel tiebacks with turnbuckle, Oversized to allow for corrosion**
  - **Drains: 2 x 2” dia holes with wire mesh/geotextile backing, located under water to prevent freezing**





- **Recent Examples Viewed**
  - **Fiberglass**







- **Recent Examples Viewed**
  - **Vinyl**





DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227

- **Construction**
  - **October 2004 – April 2005 (within the November-March dredging window)**
  - **Two barges, three cranes, clam shell, dozer, supply boats, Crew of 20**
  - **Hydraulic Dredge**
  - **Hydraulic vibratory hammer**
  - **Design called for vinyl or fiberglass; Contractor Submitted fiberglass sheeting with polyurethane resin (delivery and QC problems resulted in switch to different manufacturer and polyester resin)**
  - **Total length of two bulkheads = 1,700 feet**
  - **Sheet panel length = 27 feet (5 feet cut off to obtain required 22 feet)**
  - **Construction cost = $3 million**

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227



MATERIAL: FRP

WEST BULKHEAD - EAST WALL

DATE DRIVEN	SHEET LOCATION	GROUND ELEV.	TIP ELEV.	SHEET LENGTH	DRIVEN LENGTH	CUTOFF LENGTH	DRIVING TIME H.M.S	VIBRO MODEL	VIBRO WEIGHT	VIBRO FREQUENCY	CUTOFF LENGTH
	1100		-18.5	25'		5	80	216 ICE	5350		
	1097	1.5	-18.5	25'		5	80	216 ICE	5350		
	1094	1.5	-18.5	25'		5	80	216 ICE	5350		
	1091	1.5	-18.5	25'		5	80	216 ICE	5350		
	1088	1.5	-18.5	25'		5	80	216 ICE	5350		
	1085	1.5	-18.5	25'		5	80	216 ICE	5350		
	1082	1.5	-18.5	25'		5	80	216 ICE	5350		
	1079	1.5	-18.5	25'		5	80	216 ICE	5350		
	1076	1.5	-18.5	25'		5	80	216 ICE	5350		
	1073	1.5	-18.5	25'		5	80	216 ICE	5350		
	1070	1.5	-18.5	25'		5	80	216 ICE	5350		
	1067	1.5	-18.5	25'		5	80	216 ICE	5350		
	1064	1.5	-18.5	25'		5	80	216 ICE	5350		
	1061	1.5	-18.5	25'		5	80	216 ICE	5350		
	1058	1.5	-18.5	25'		5	80	216 ICE	5350		
	1055	1.5	-18.5	25'		5	80	216 ICE	5350		
	1052	1.5	-18.5	25'		5	80	216 ICE	5350		
	1049	1.5	-18.5	25'		5	80	216 ICE	5350		
	1046	1.5	-18.5	25'		5	80	216 ICE	5350		
	1043	1.5	-18.5	25'		5	80	216 ICE	5350		
	1040	1.5	-18.5	25'		5	80	216 ICE	5350		
10/28/2004	1037	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1034	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1031	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1028	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1025	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1022	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1019	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1016	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1013	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1010	1.5	-18.5	27		5	80	216 ICE	5350		
10/28/2004	1007	1.5	-18.5	27		5	80	216 ICE	5350		

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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19/11/2004

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DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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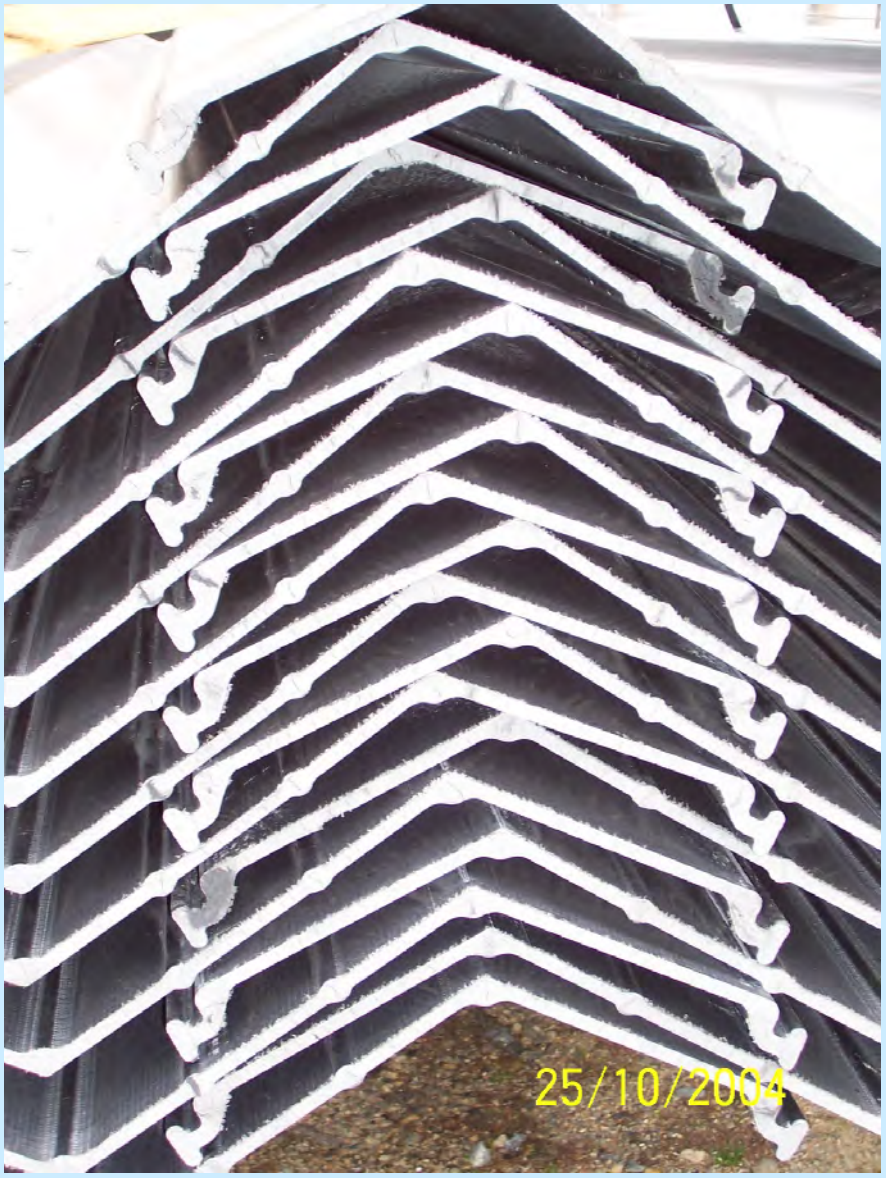
Field Issues & Lessons Learned

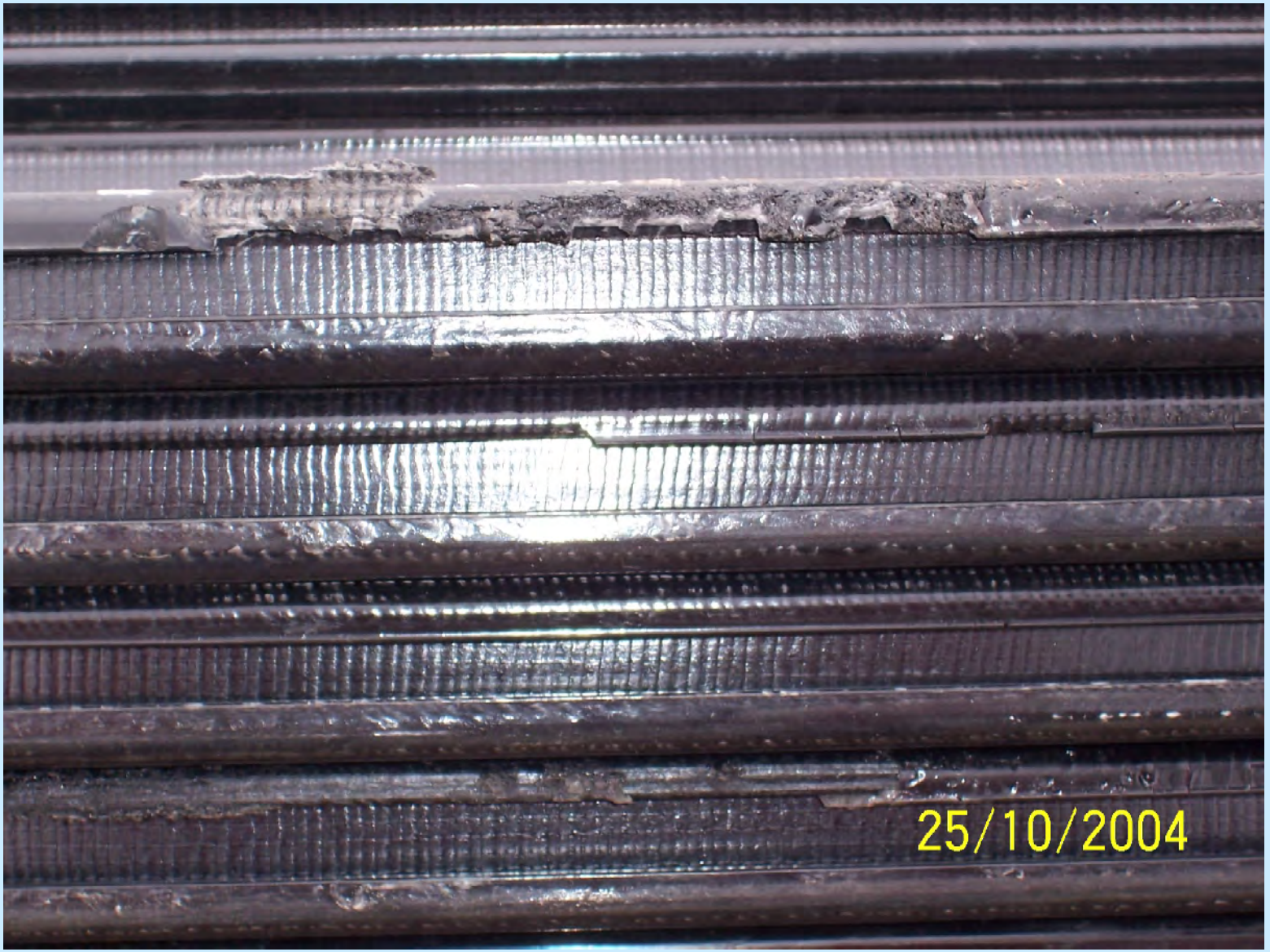


DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227

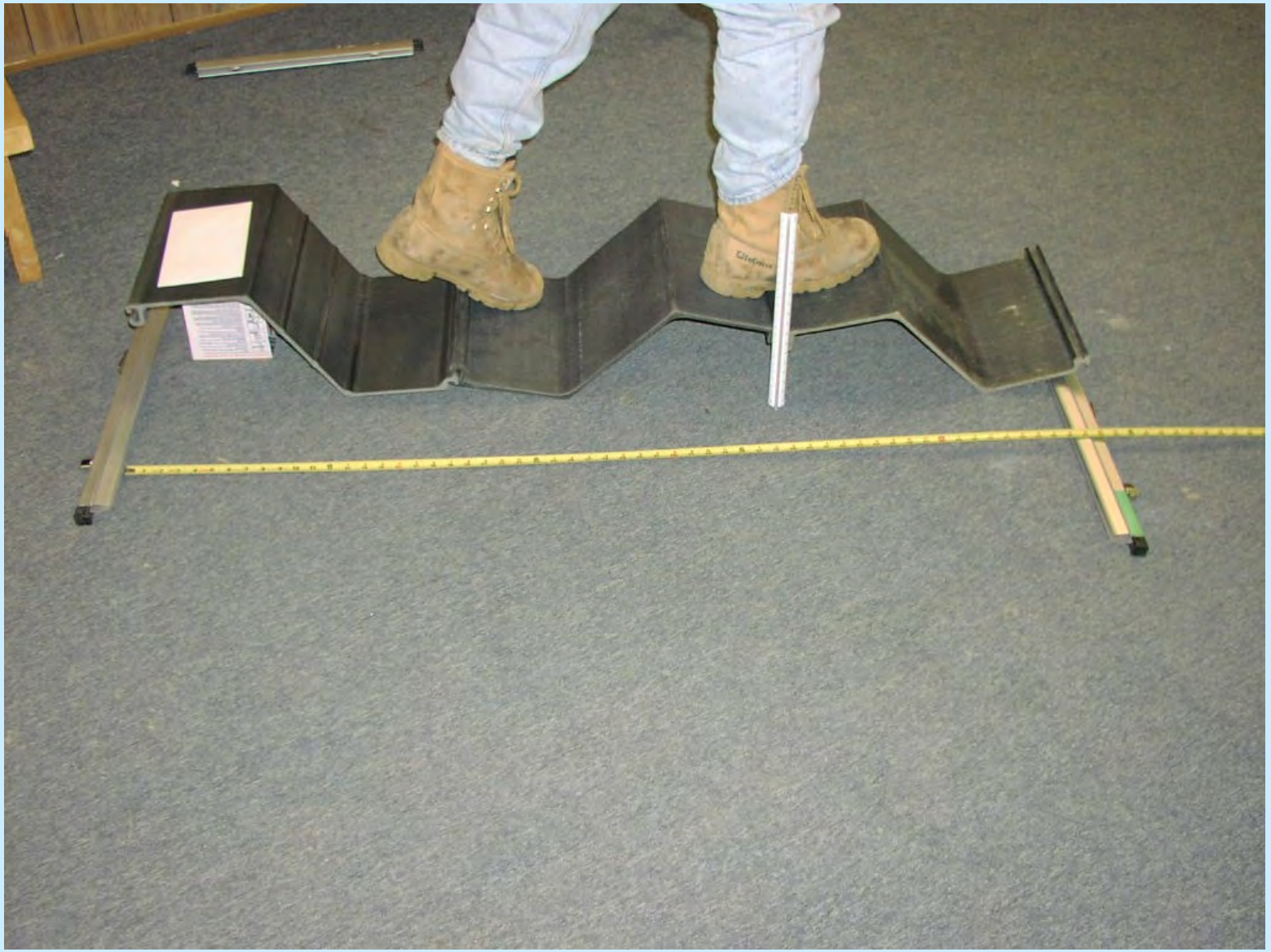



25/10/2004


25/10/2004

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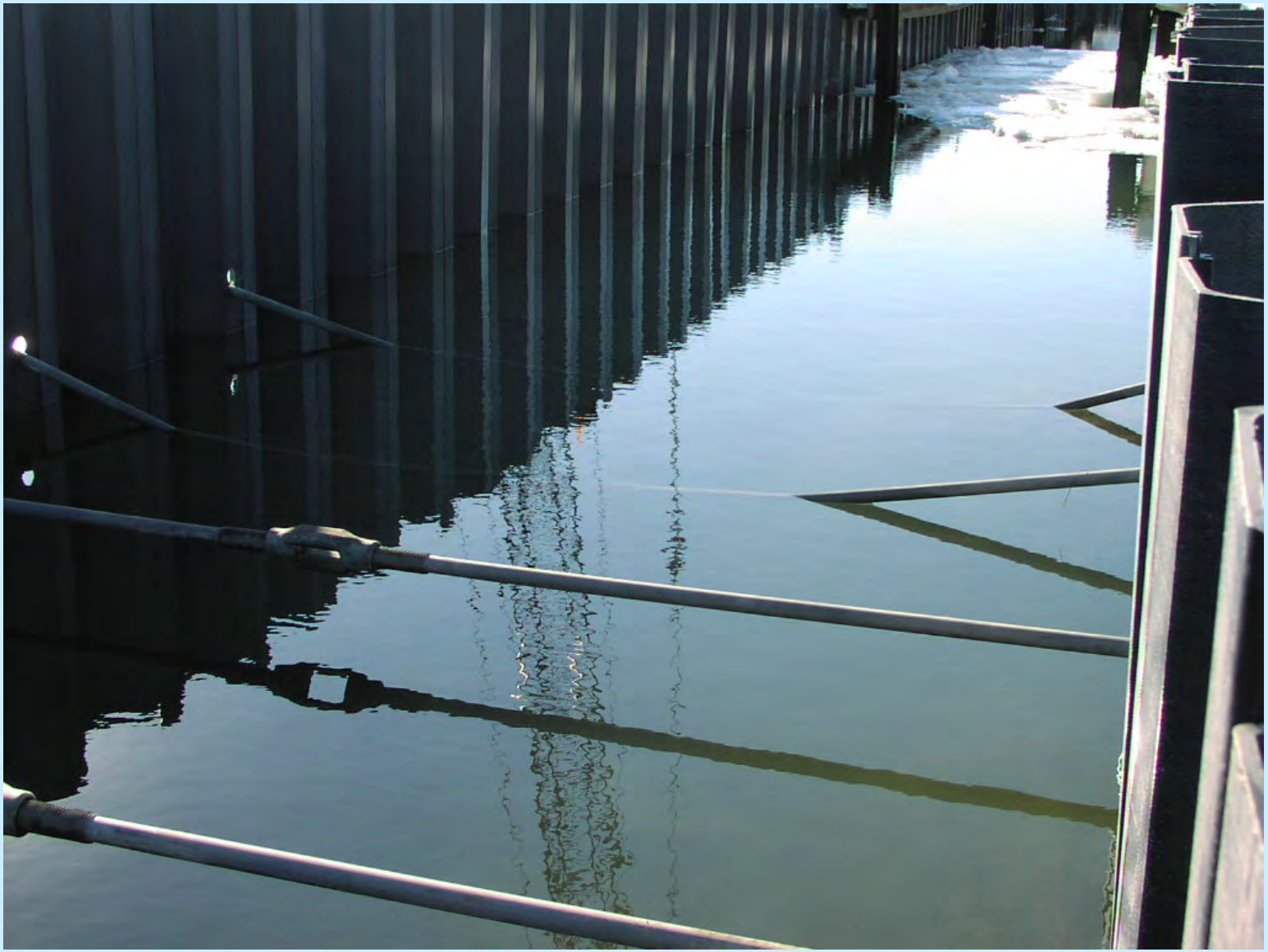
DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

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SECTION 227



Instrumentation

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

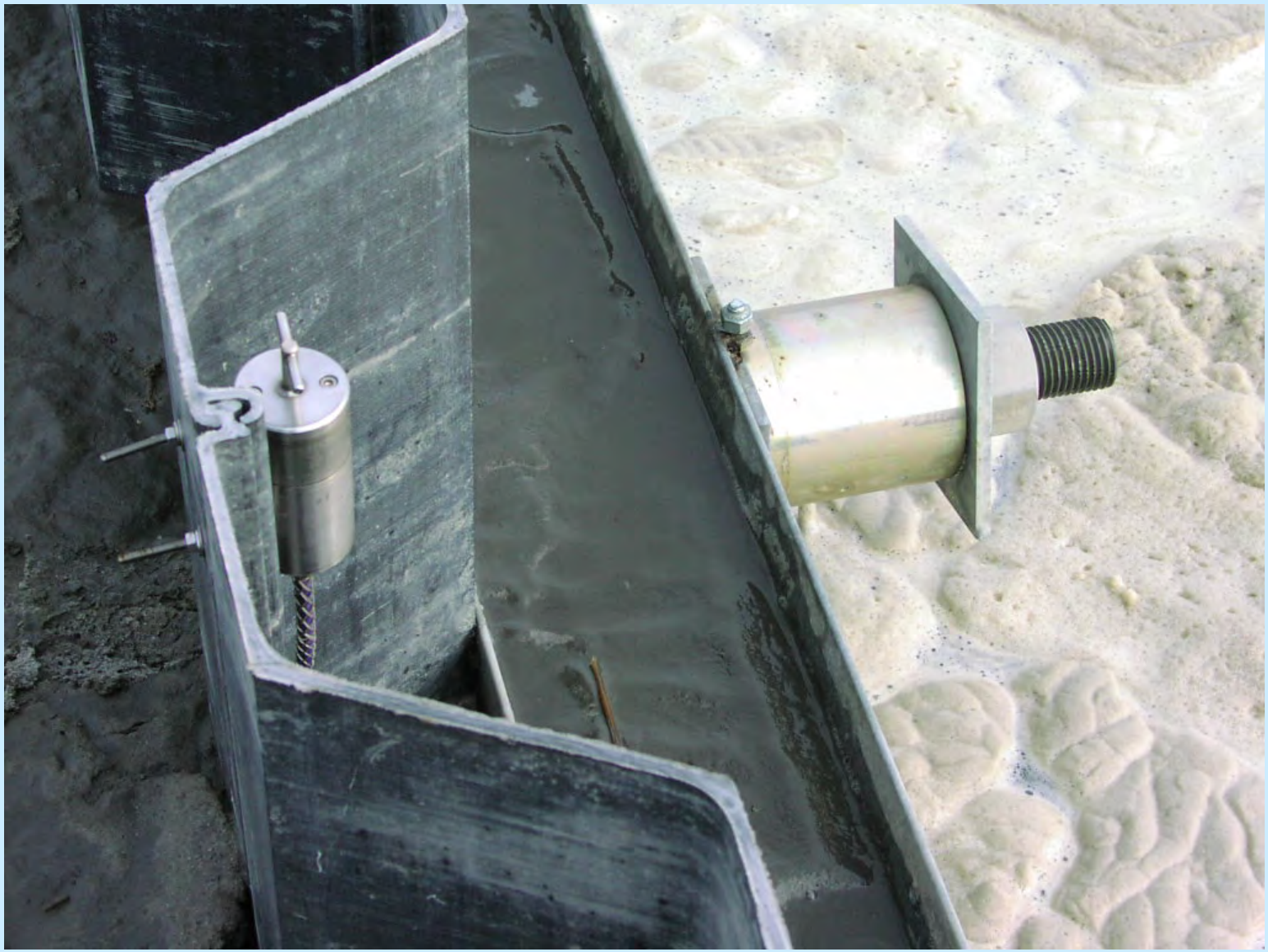
SECTION 227



Location Station	Date	Time	Well Reading	Well Level MLW	Tide Reading	Tide Level MLW	Delta (Well - Tide)
W4+00…							
1	4/14/05	1049	42"	+1' 11"	36"	+0' 6"	+1' 5"
2	4/15/05	1000	30"	+2' 11"	26.5"	+1' 3.5"	+1' 7.5"
3	4/18/05	1317	34"	+2' 7"	29.5"	+1' 0.5"	+1' 6.5"
4A	4/19/05	1335	29.5"	+2' 11.5"	24.5"	+1' 5.5"	+1' 6"
4B	4/19/05	1440	36.5"	+2' 4.5"	31.5"	+0' 10.5"	+1' 6"
5	4/20/05	1451	33"	+2' 8"	31.5"	+0' 10.5"	+1' 10.5"
6	4/25/05	0659	38.5"	+2' 3"	40.5"	+0' 1.5"	+2' 1.5"

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227




TOPCON
OFFSET

Deformation Monitoring Log

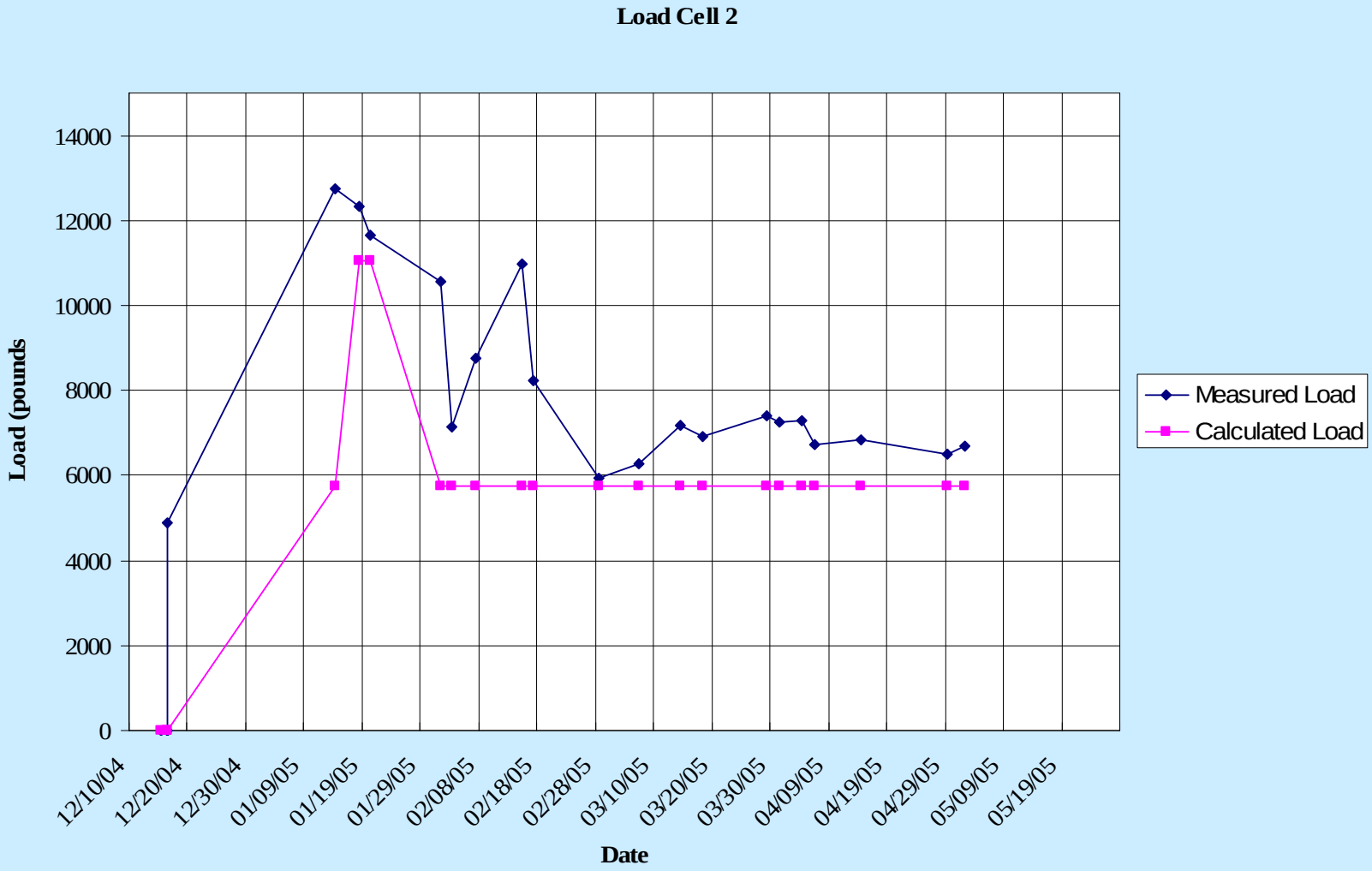
Date:	4/6/2005
Time:	2:30 PM
Project:	Seabrook Harbor Section 227 Project
Temp:	58°F BP 30.24
Contract No.:	W912WJ-04-C-0009
Weather:	FAIR
Surveyed By:	W. Saucier

Reading Number	Location	Direct Angle	Inverse Angle	Average Angle	Direct Distance	Inverse Distance	Average Distance	Elevation	Deformation From Initial Reading
1	1+38 E	39°39'35"	39°39'39"	39°39'37"	88.24	88.245	88.24	1.77	E 0.069/N 0.00
2	1+38 E	39°39'36"	39°39'42"	39°39'39"	88.235	88.24	88.24	1.77	E 0.068/N 0.00
3	1+38 E	39°39'39"	39°39'41"	39°39'40"	88.245	88.235	88.24	1.77	E 0.068/N 0.00
								0.02	
					Change from initial (inches)				0.83
1	1+60 E	39°34'54"	39°35'00"	39°34'57"	110.025	110.035	110.03	1.82	E 0.044/N 0.00
2	1+60 E	39°34'55"	39°34'57"	39°34'56"	110.03	110.03	110.03	1.82	E 0.044/N 0.00
3	1+60 E	39°35'00"	39°34'54"	39°34'57"	110.035	110.03	110.03	1.82	E 0.044/N 0.00
								0	

Comments

Note: Initial Readings (1+38E 39°42'19" - 88.24 / 1+60E 39°36'19" - 110.03)

Third reading on completed wall


Load Cell 2
Load (pounds
14000
12000
10000
8000
6000
4000
2000
0
12/10/04
12/20/04
12/30/04
01/09/05
01/19/05
01/29/05
02/08/05
02/18/05
02/28/05
03/10/05
03/20/05
03/30/05
04/09/05
04/19/05
04/29/05
05/09/05
05/19/05
Date
Measured Load
Calculated Load

- **Conclusions**
  - **Pick the right application. Despite some manufacturers' claims, steel it is not!**
  - **Synthetic sheeting can be very cost effective (50% of cost of steel is possible)**
  - **Conservatism in design is recommended because of scarcity of test data.**
  - **Construction sequence is crucial to avoid overstressing the material**
  - **Synthetic sheeting is here to stay**

- **Current Needs**
  - **Standard (full scale panel) test methods & corresponding data**
  - **Standard guide specifications**
  - **Long term performance data (longevity)**
  - **Greater number of quality manufacturers**
  - **Information exchange among designers (USACE, NAVY, Others)**
  - **A committee to facilitate the exchange and develop standards**

& our final product….

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES, SEABROOK, NEW HAMPSHIRE

SECTION 227



October 2004



April 2005

SECTION 227

DESIGN AND CONSTRUCTION OF ANCHORED BULKHEADS WITH SYNTHETIC SHEET PILES SEABROOK, NEW HAMPSHIRE



Thank you

siamac.vaghar@usace.army.mil

Unlined Spillway Erosion Risk Assessment

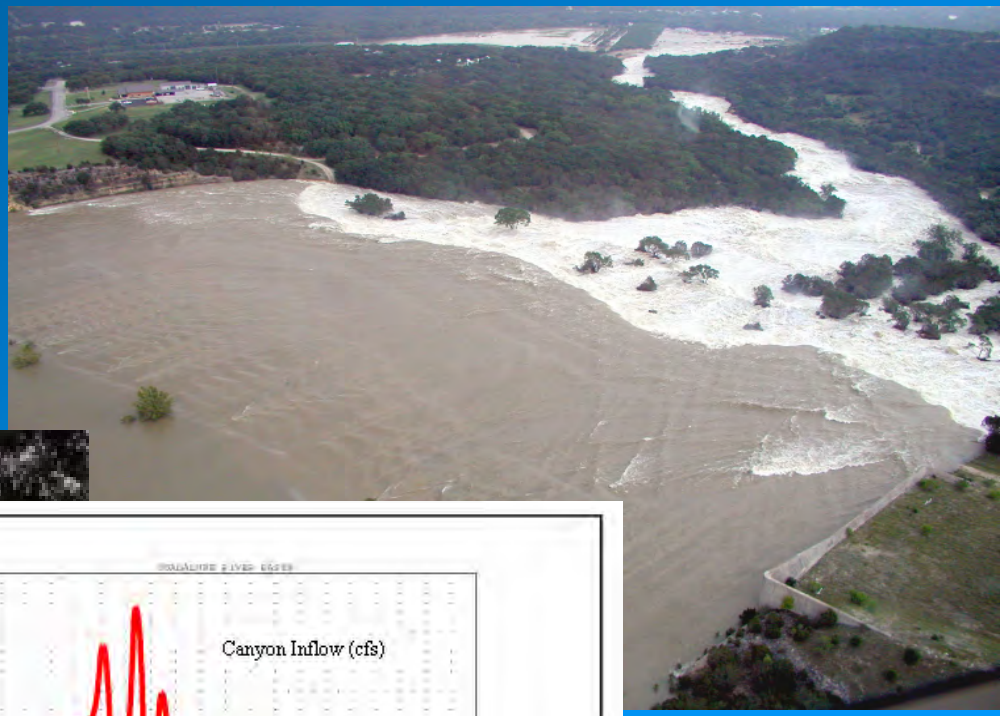

Tuttle Creek, KS

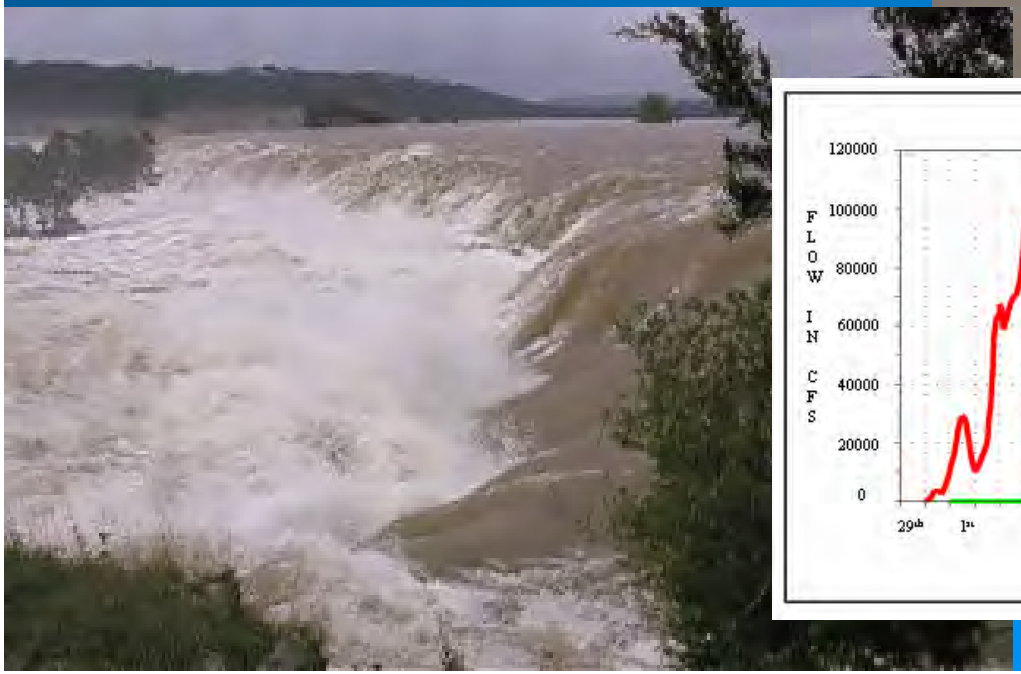
Johannes Wibowo
Don Yule
Evelyn Villanueva
U.S. Army COE ERDC

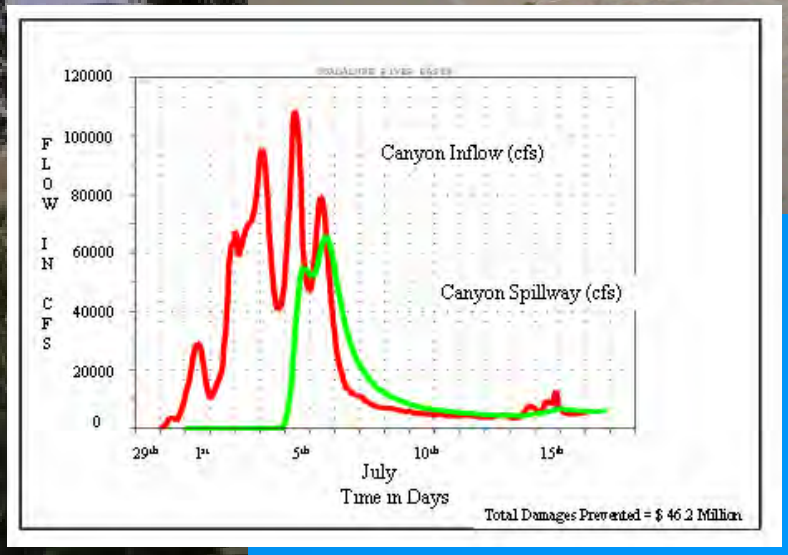
Darrel Temple USDA

Introduction

Canyon Dam Spillway, Texas
Date: July 6, 2002
Flow: 66,000 cfs, 250 yr flood
Duration: 12 days
Spillway Width: 1260 ft
Material: Limestone



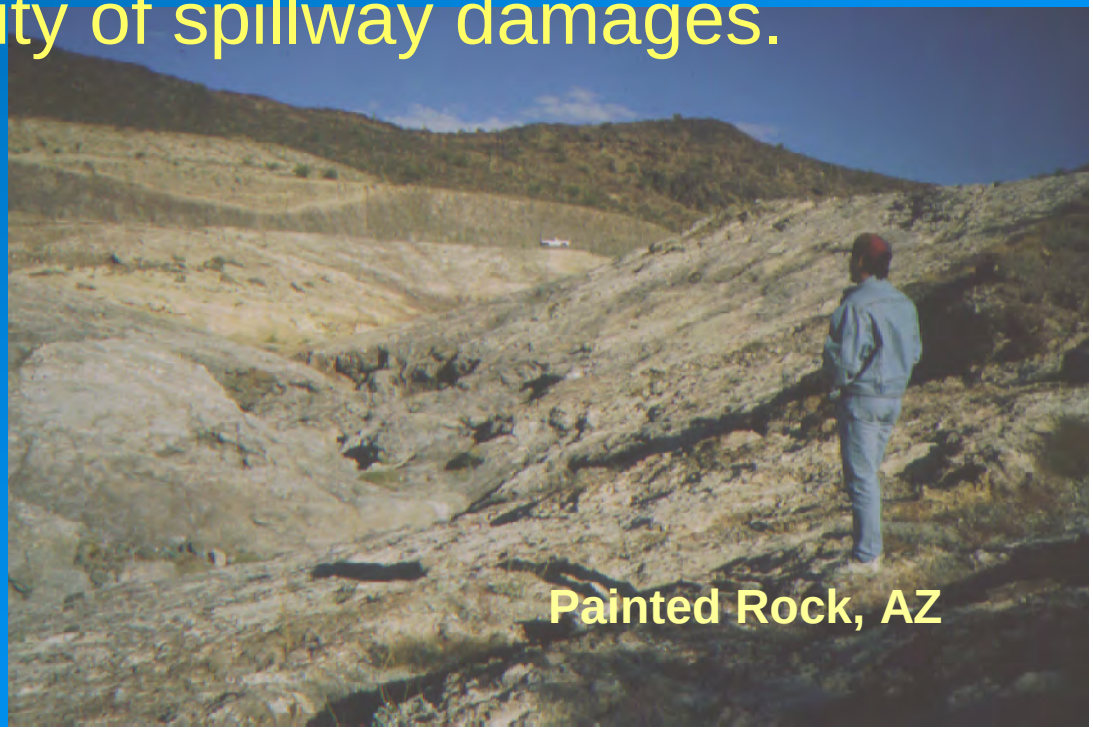




Introduction

Problem Statements:

- Spillway erosion analysis encounters variable nature of geometry, geologic material, and unpredictable flood events.
- Dam Safety Port Folio Analysis needs a tool to determine the probability of spillway damages.



Painted Rock, AZ

Introduction

RESEARCH OBJECTIVES:

- Develop a tool to assess the probability of damages on unlined spillway erosion



Risk Assessment

Process of Answering Three Questions:

1. What can go wrong?
2. What is the likelihood it will go wrong?
3. What are the consequences if it does go wrong?

Risk Assessment

1 What Can Go Wrong?



Local Scouring



Headcut Erosion



Spillway Breach



Dam Breach

Risk Assessment

2 What Is the Likelihood It Will Go Wrong?

- Uncertainty of Flood Event
- Uncertainty of Material Parameters
- Uncertainty of Performance of the Unlined Spillway

Risk Assessment

3 What Are the Consequences If It Does Go Wrong?

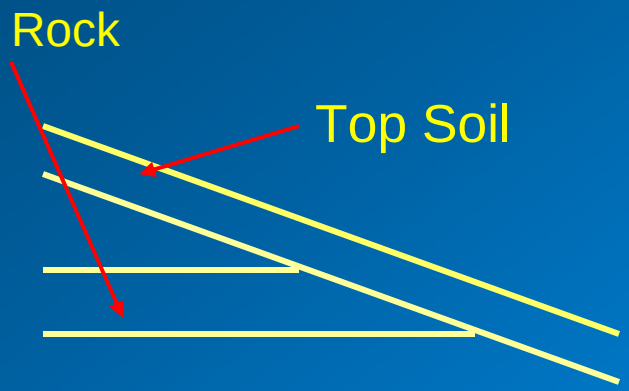
- Spillway Partial Damage
  - Lightly Damaged
  - Moderately Damaged
  - Severely Damaged
- Spillway Breach
  - Population at Risk
  - Loss of Economic Value

Spillway Erosion Models

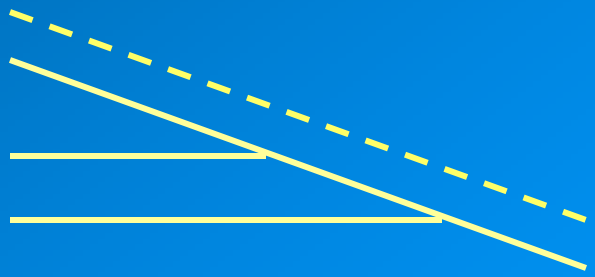
- REMR (WES, 1998)
- USDA (Temple et al., 1994)
- Annandale (1995)
- Bollaert (2002)

Spillway Erosion Models

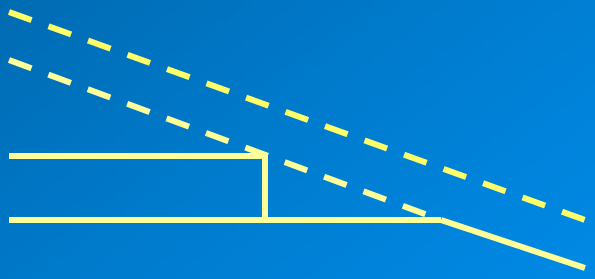
Phases of Erosion



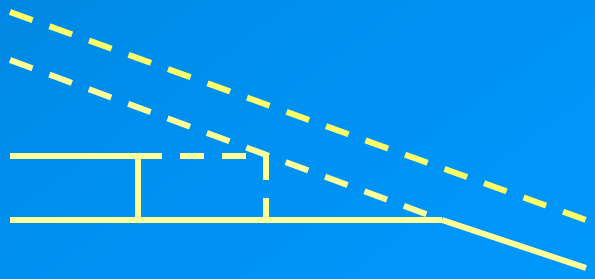
Original Surface



Vegetal Detachment

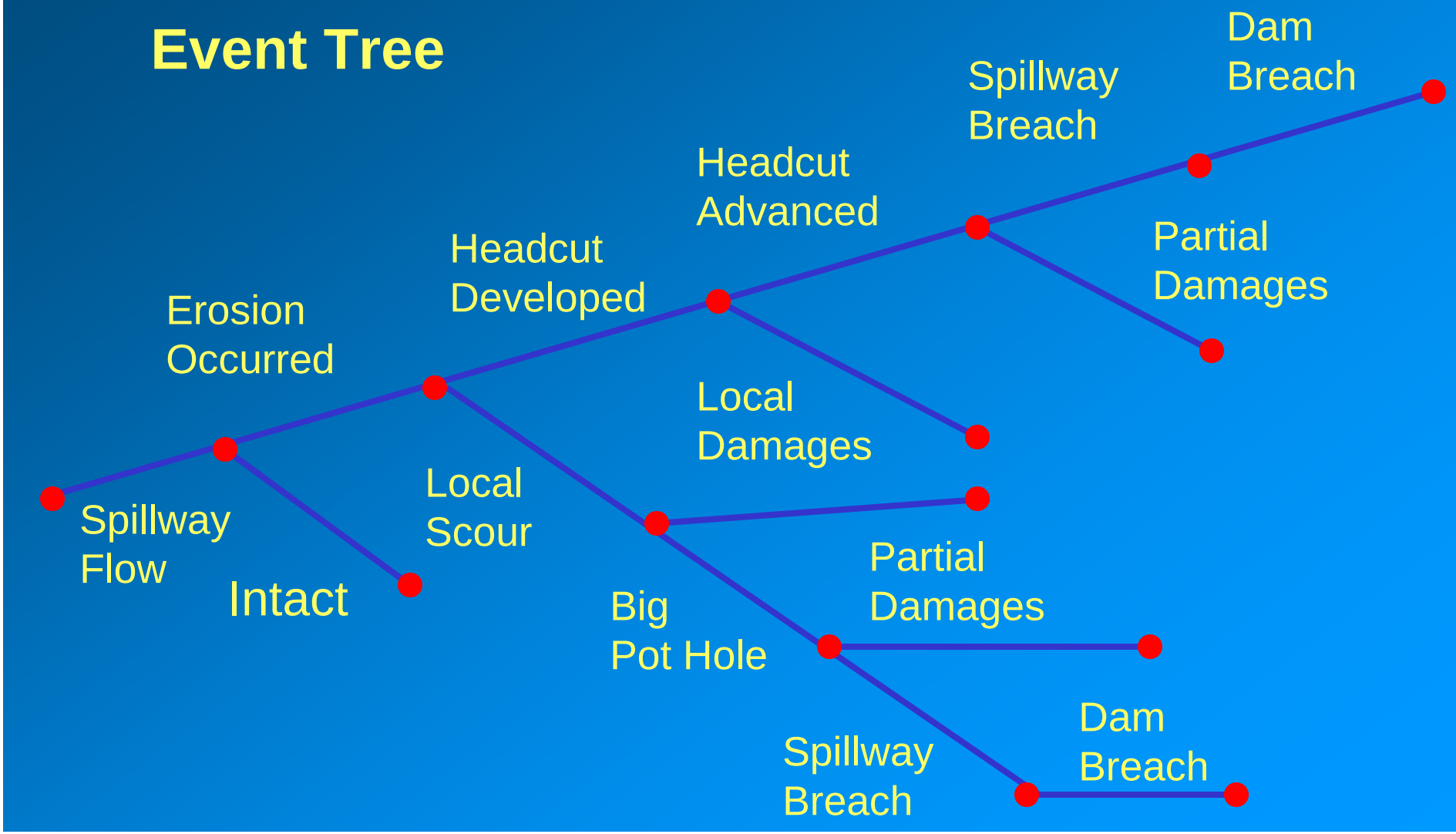


Head-cut Development



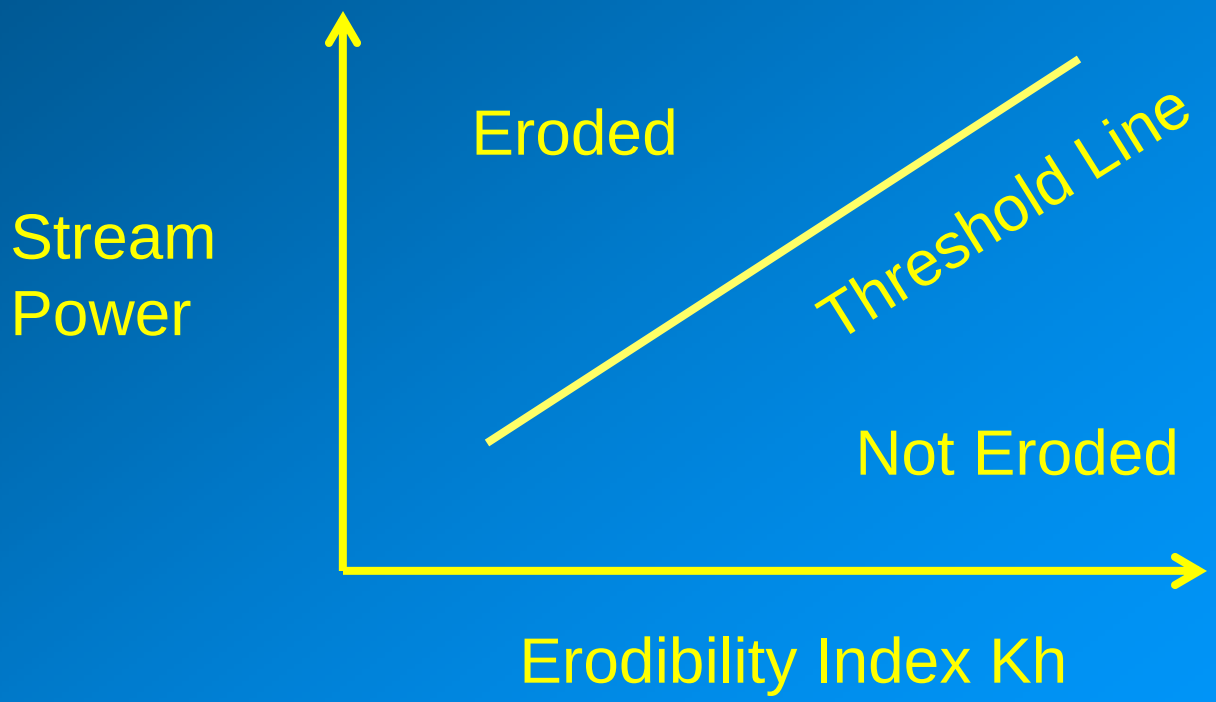
Head-cut Advancement

Erosion Process



Erosion Model - Threshold Line

Erosion Model - Threshold Line



Erosion Model - Threshold Line

Erodibility Index (K_h)

$$K_h = M_s * K_b * K_d * J_s$$

M_s = Material Strength Number

K_b = Block Size Number

K_d = Joint Shear Strength Number

J_s = Joint Orientation Number

Erosion Model - Threshold Line

Stream Power

$$P = \gamma * q * S_f$$

P = Stream Power

γ = Unit weight of water

q = Unit discharge

S_f = Energy Slope

Logistic Regression

- Regression for Binary Outcomes
  - Occurrence (Erosion)
  - Non-Occurrence (No Erosion)
- User of Logistic Regression Method
  - Medical
  - Business
- Probabilistic Liquefaction Analysis (Liao et al, 1988)

Logistic Regression

- Odds ratio $\dfrac{p}{1 - p}$
- Logit transformation

$$Ln\left[\frac{p}{1-p}\right] = b_0 + b_1 x$$

$$p = \frac{1}{1 + \exp\left[-\left(b_0 + b_1 x\right)\right]}$$

p = probability of occurrence

b_0, b_1 = regression parameters

x = independent variable

Logistic Regression

Multiple Logistic Regression

$$p = \frac{1}{1 + \exp\left[-\left(b_0 + b_1 x_1 + b_2 x_2 + .. + b_n x_n\right)\right]}$$

p = probability of occurrence

b_0, b_1, b_2, .., b_n = regression parameters

x_1, x_2, .., x_n, = independent variables

Logistic Regression

Multiple Logistic Regression for Spillway Erosion

$$p = \frac{1}{1 + \exp\left[-\left(b_0 + b_1 K_h + b_2 qH\right)\right]}$$

K_h = Erosion Index, Material Resistance

qH = Hydraulic Attack

Logistic Regression

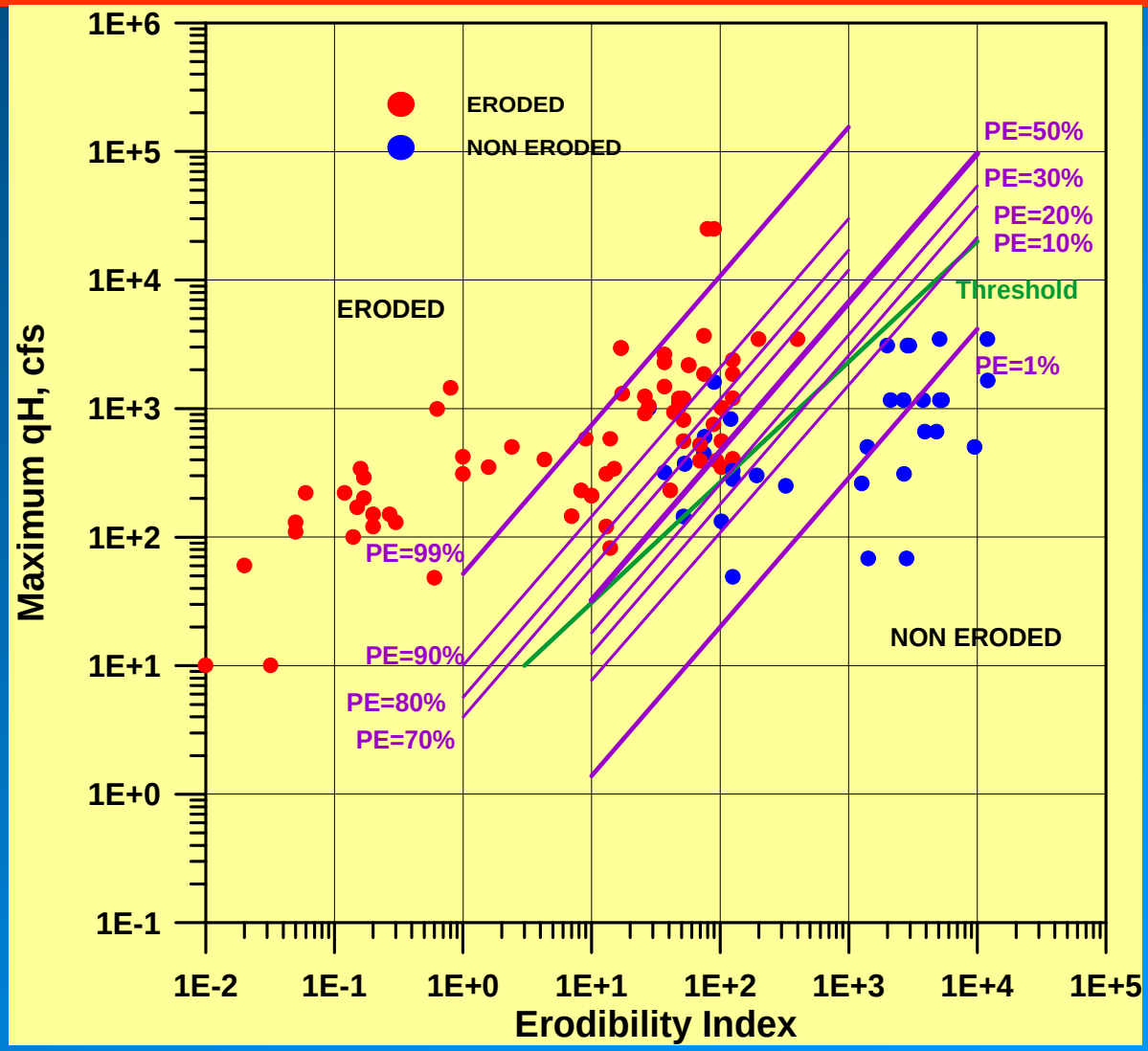
Result of Multiple Logistic Regression

$$p_e = \frac{1}{1 + \exp\left[-\left(1.171 - 3.9 K_h + 3.364\, qH\right)\right]}$$

Nagelkerke's $R^2 = 0.763$

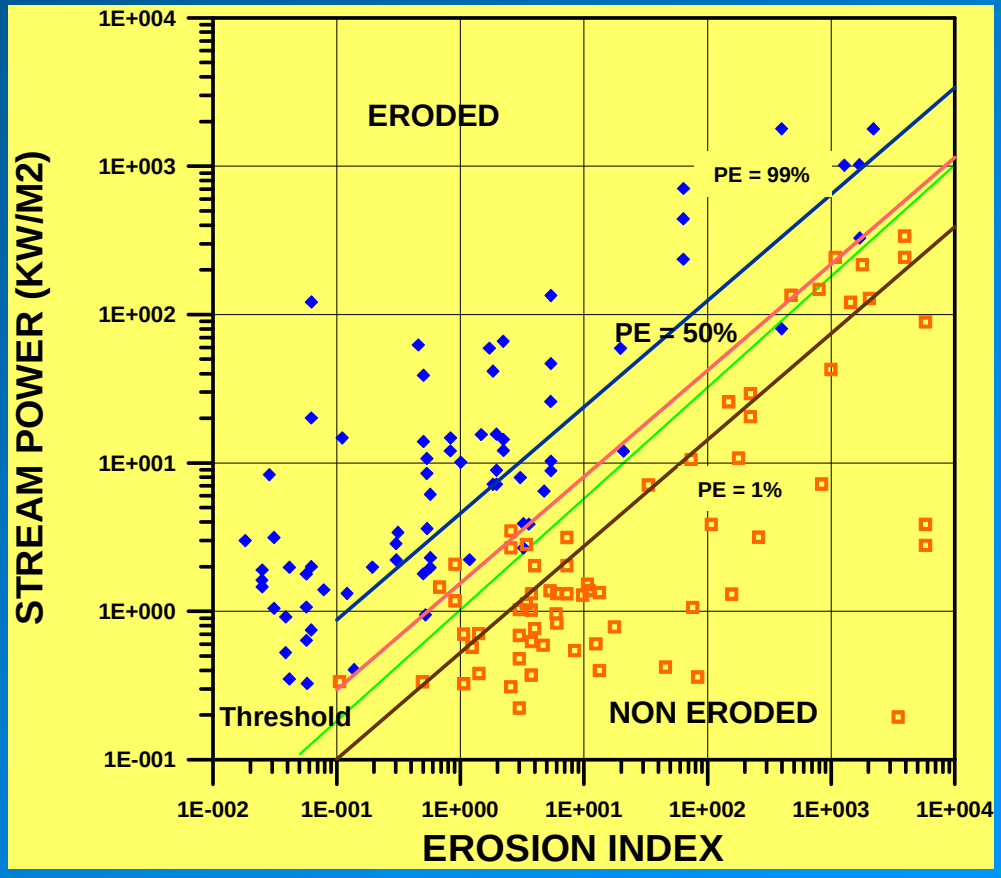
p_e = probability of erosion
K_h = Erosion Index, Material Resistance
qH = Maximum qH, Hydraulic Attack

Logistic Regression



Logistic Regression for ERDC Threshold

Logistic Regression



Logistic Regression for Annandale Threshold

Ordinal Logistic Regression

Independent Variables

- Hydrograph
  - Peak unit discharges (cfs/ft)
  - Flood durations (hrs)
- Spillway Geometry
  - Lengths (ft)
  - Slopes (degrees)
- Material Index
  - Erosion Indexes

Ordinal Logistic Regression

Sj = F (Material, Peak Discharge, Duration, Average_Slope, and Length)

Data: Case Histories (USDA and COE)

Damage Levels	Percent of Erosion
No Damage	0 - 0.05%
Light Damage	0.06 – 15%
Moderate Damage	16 – 40%
Severe Damage	41 – 75%
Breach	76 – 100%

Ordinal Logistic Regression

Sj = -1.515 Log_Kh + 8.635 Log_q – 1.581Log_Dura
+ 0.807 Slope_av + 3.975 Log_Length

Nagelkerke's $R^2 = 0.727$

Probability Formulation:

No Damage	= 1/(1+ exp(Sj-k1))
Light Damage	= 1/(1+ exp(Sj-k2)) - 1/(1+ exp(Sj-k1))
Moderate Damage	= 1/(1+ exp(Sj-k3)) - 1/(1+ exp(Sj-k2))
Severe Damage	= 1/(1+ exp(Sj-k4)) - 1/(1+ exp(Sj-k3))
Breach	= 1 – 1/(1+ exp(Sj-k4))

k1,k2, k3, and k4 = boundary parameters from regression

Ordinal Logistic Regression

Input	Tuttle Creek KS Ls-Sh	Painted Rock AZ Felsite	Painted Rock AZ Tuff	Saylorville IA Ss-Sh	Buck_Doe MO Clay
Unit Disch. (cfs/ft)	112.1	41.8		104.4	163.5
Duration (hours)	120	576		216	3
Erosion Index, K_h	17	5340	28	103	0.01
Ave. Slope (deg)	1.4	1.32	14.04	1	7.2
Length (ft)	2200	520	230	1340	155
Probability Output					
No Damage	0.001	0.990	0.000	0.029	0.000
Light	0.019	0.009	0.002	0.275	0.000
Moderate	0.305	0.001	0.047	0.609	0.000
Severe	0.629	0.000	0.639	0.085	0.003
Breach	0.046	0.000	0.312	0.002	0.997

Logistic Regression





	The Dalles, OR Q=2,290,000 cfs	Bluestone. WV Q=430,000 cfs
Erosion Index (Kh)	1960	2734
Stream Power (Kw/m2)	125.4	22.3
Probability of Erosion	0.012	0.000

Unlined Spillway Erosion Risk Assessment

Prioritizing Process

Ranking the outcome:

$$Risk = P_{occurrence} * P_{failure} * Consequences$$

Summary

- Two Risk Assessment tools were developed for Port Folio analysis:
  - Logistic Regression Formulation for calculating the probability of erosion
  - Ordinal Logistic Regression for calculating the probability of erosion of different levels of damages
- These tools will be useful for prioritizing the maintenance of earth and rock surface unlined spillway


Carretera
Fernando Belaunde Terry
Campanilla-Pto Pizana
W91278-04-C-0011
ANDRADE GUTIERREZ
Construtora Andrade Gutierrez SA
USAID
MTC

Peru Road Upgrade Project

U.S. Army Corps of Engineers
Mobile District
Latin America Area Office

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Chile
Perú

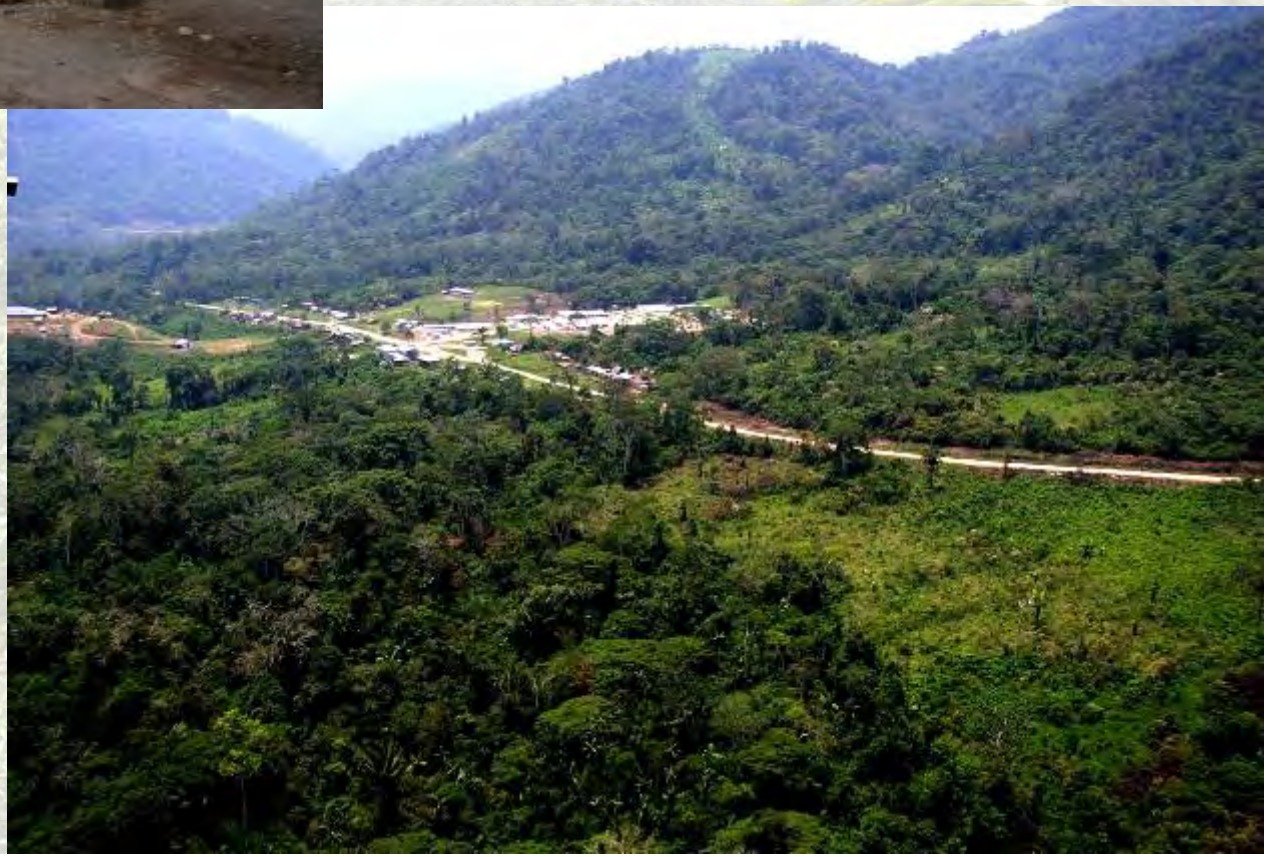
U.S. Army Corps of Engineers – Andrade Gutierrez
Sections II & III

Section	Km	Responsible
Section I Juanjui – Campanilla	44.4	PROVIAS NACIONAL
Section II **Campanilla – Pizarron**	**44.7**	ANDRADE GUTIERREZ Construtora Andrade Gutierrez SA
Section III **Pizarron – Puerto Pizana**	**46.2**	ANDRADE GUTIERREZ Construtora Andrade Gutierrez SA
Section IV Pizana – Tocache	41.3	PROVIAS NACIONAL


NUEVO PUCACACA
TARAPOTO
POLISH
CHAZUTA
11 km
SAN FRANCISCO
LAS FLORES DE MAMONAQUIHUA
SAUCE
SANTA ROSA
STA. ROSILLO DE UPAQUIHUA
ZAPOTILLO
123.1 km
PICOTA
CASPISAPA
SHAMBOYACU
BELLAVISTA
SACANCHE
PUENTE TINGO DE SAPOSOA
JUANJUI
AERODROMO DE JUANJUI
44.4 Km
ALTO HUALLAGA
CAMPANILLA
172 Km
Section II
NVO. JAEN
44.7 Km
SAN MARTIN
176.2 km
PIZARRON
NVO. SAN MARTIN
BALSAYACU
46.2 Km
Section III
POLVORA
PIZANA
41.3 Km
TOCACHE
COLOMBIA
ECUADOR
LORETO
BRAZIL
BOLIVIA
Peru



AG Base Camp
Nuevo San Martin



Local Areas Affected

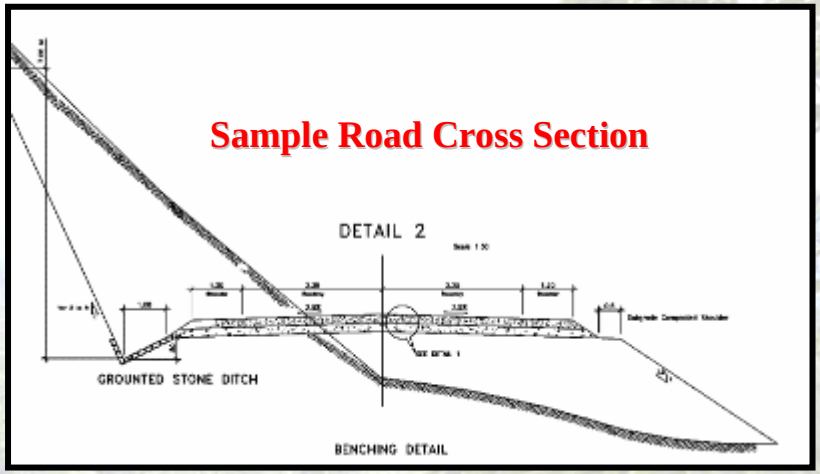




Original Design Improvements for Sections II & III

Section II: 44.68 km
Campanilla-Pizarron

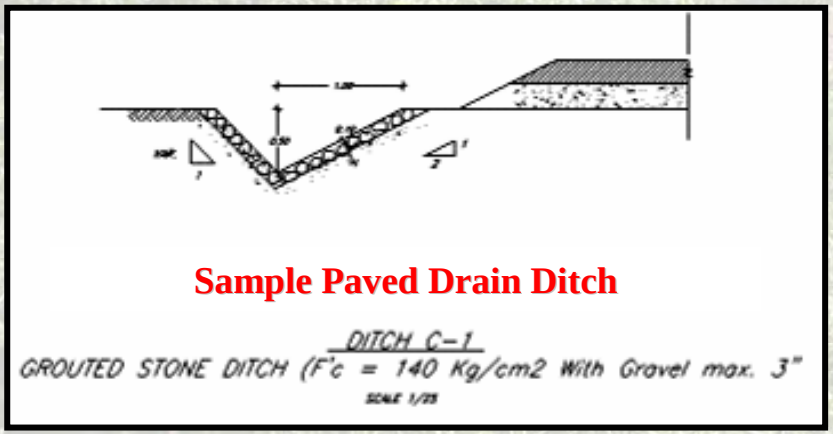
- Road Widening - 6.6 m
- Culverts replaced, added, or improved – approximately 270
- Subdrainage & Ditching added
- Retaining Walls
- Bridges added - 5



Sample Road Cross Section

Section III: 46.2 km
Puerto Pizana-Pizarron

- Road Widening - 6.6 m (var.)
- Culverts replaced, added, or improved – approximately 203
- Subdrainage & Ditching added
- Retaining Walls
- Bridges added - 7



Sample Paved Drain Ditch

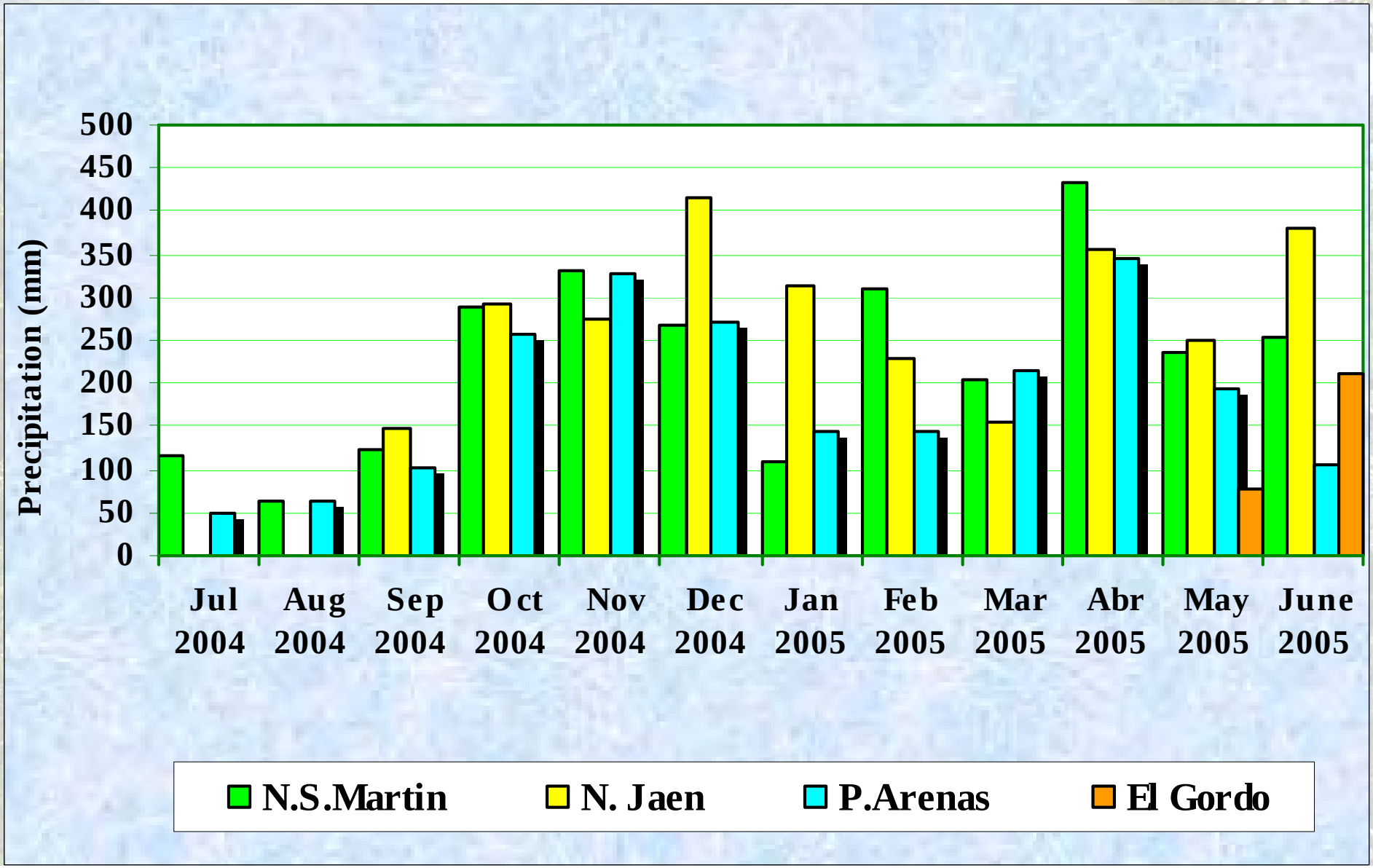
Challenges of Peru Road Project

Early Challenges

- Location – remote mountainous jungle area with limited access
- Environment – dense forest with significant rainfall
- Early condition of Road – practically impassable
- Original Design Problems, lack of foundation & slope stability studies
- Extensive variety of in-place Soil & Rock classifications
- Landslides – Cost $$$$$, damaging completed work
- Drainage and De-watering
- Overcoming common construction practices
- Personnel Security


Rainfall Events

Monthly Rainfall 2004 & 2005



Early Conditions



Early Conditions



Early Conditions



Early Conditions



Need for Management of Drainage





Improvements
Clearing
Section III





Improvements
Road Widening
Section II

Improvements in Drainage



Culvert Installations



Culvert Construction





Improvements
Low Water Crossing



Improvements
Bridge

Bridge Construction





Punta Arena Operations:
Concrete Plant



Punta Arena Operations:
Rock Crushing & Sieving Plant, Laboratory, Maintenance Facility & Materials Storage

Balsayacu Quarry



Construction Methods



Construction Methods




Construction Methods

Construction Methods



Construction Methods



Construction Methods



Construction Methods



Construction Methods



Construction Methods



Construction Methods



Construction Methods



Construction Methods




Construction Methods

Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Variety of Soil & Rock



Landslides



Landslides



Landslides






Landslide
"Before"

Landslide “After”



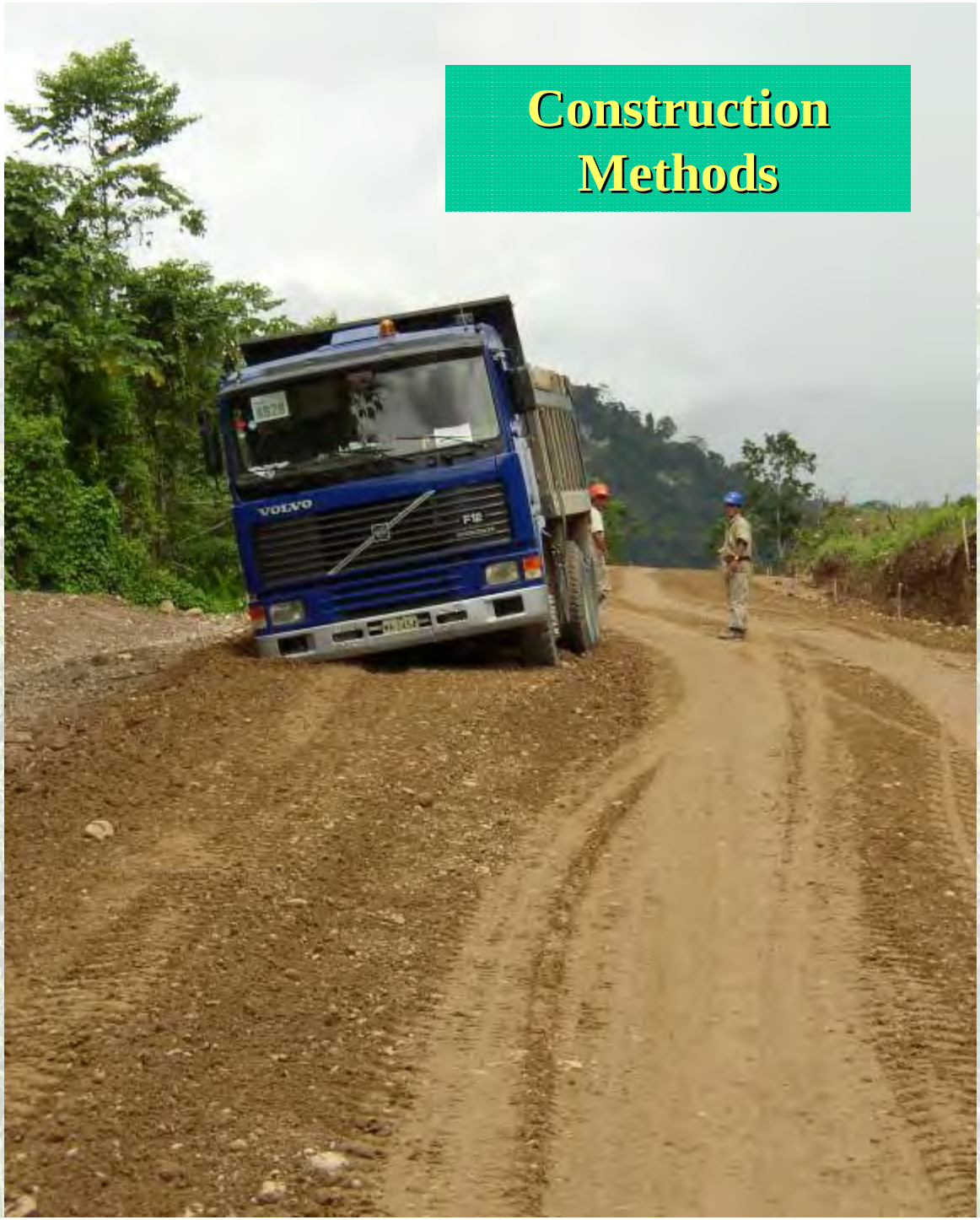
Landslides $$$ exceed Contingencies

Cost of slide cleanup offset by Re-design

- Delete unnecessary bridges, add box culverts where applicable
- Extending/reusing satisfactory culverts
- Use of nearby select granular borrow for platform stabilizing, backfill, and subbase course
- Eliminate some cuts & fills, follow the “lay of the land” where practical
- Road re-alignment away from slides
- Adjusting pavement design layers

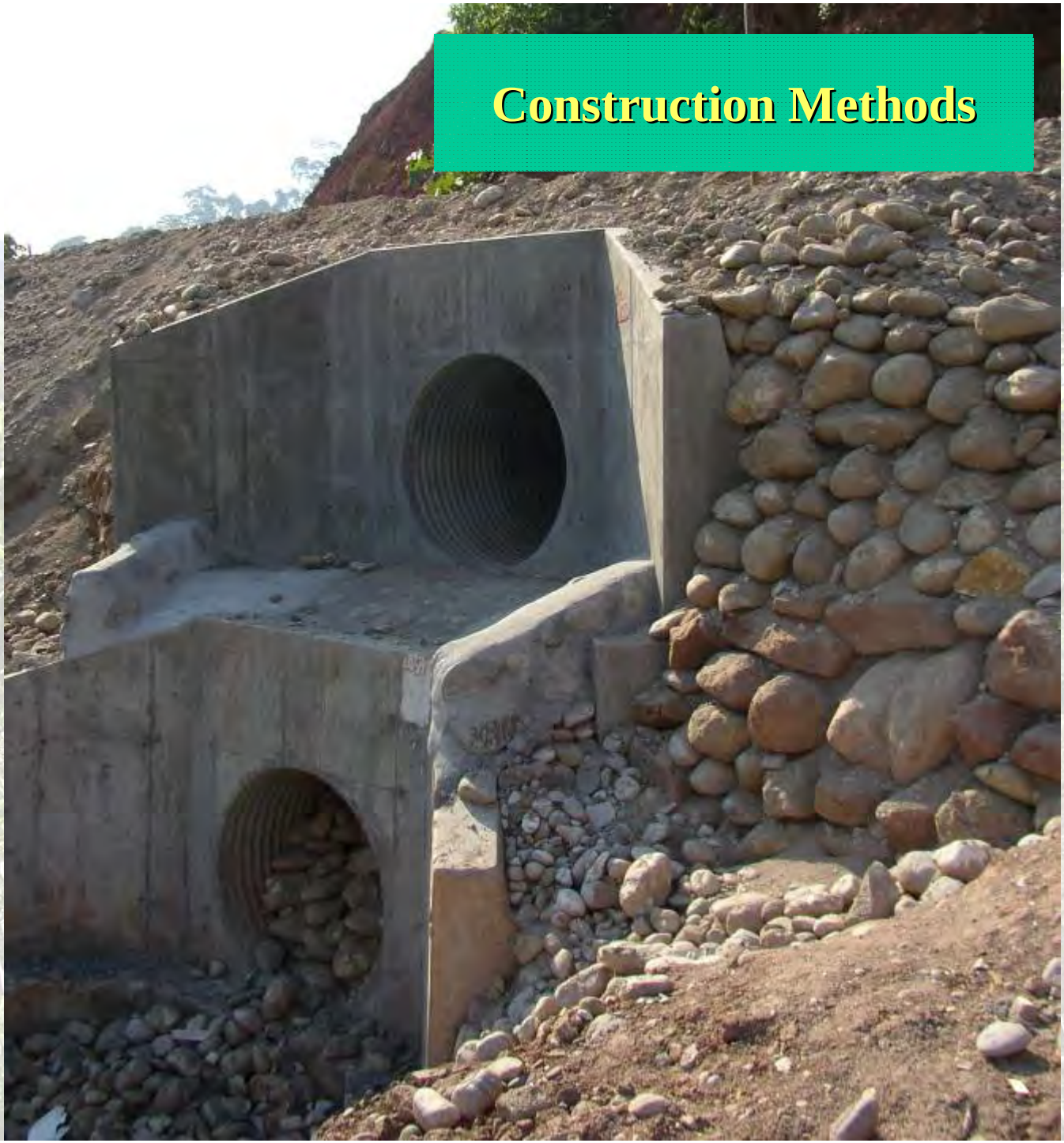

Drainage & De-watering
72"

Construction Methods




Construction
Methods

Construction Methods

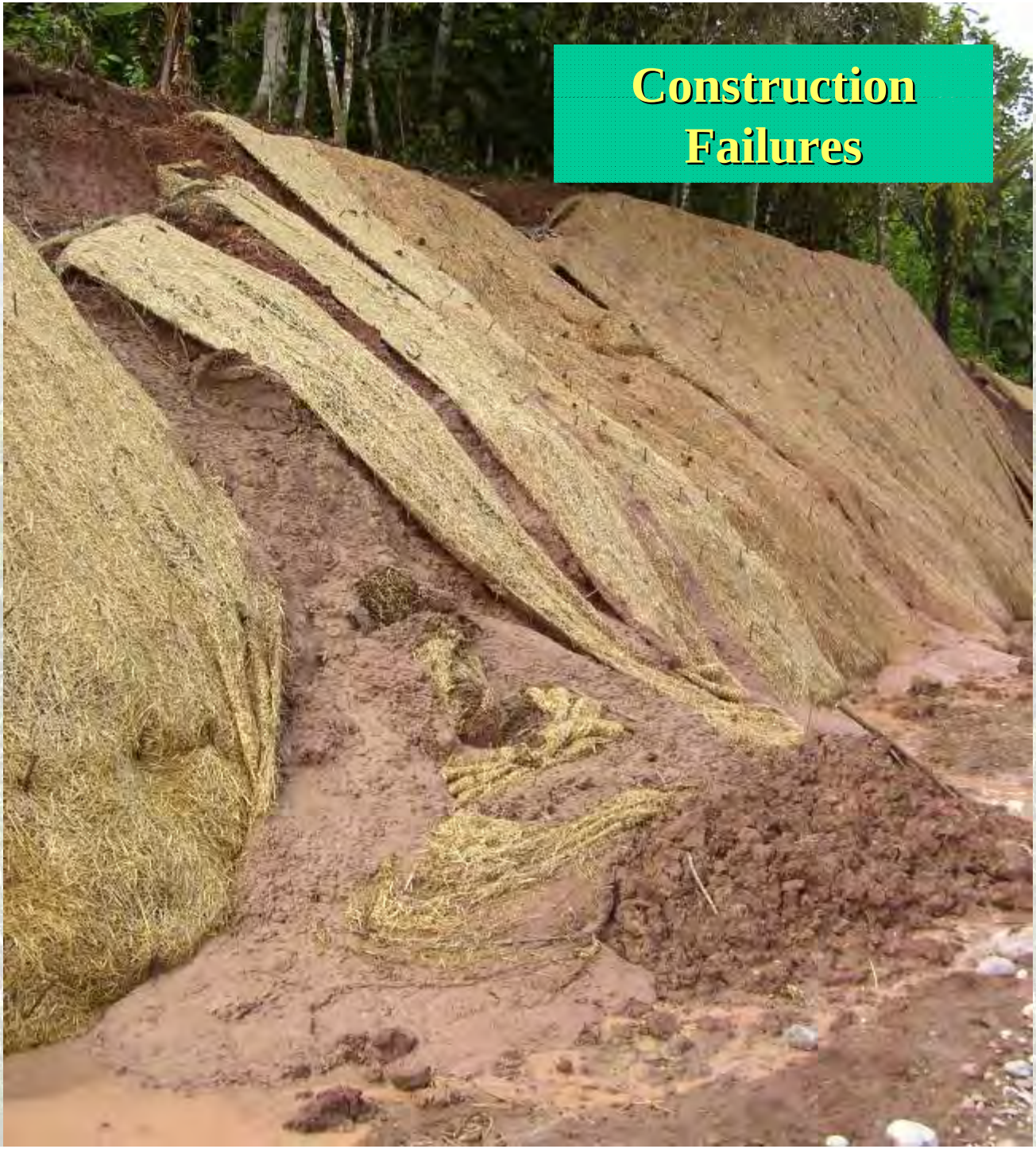


Construction Methods




Construction
Failures

Construction Failures



Personnel Security



Challenges of Peru Road Project

Lessons Learned/Solutions

- Minimize clearing & grubbing - only execute in immediate foundation areas, while promoting jungle growth
- Reduce slope cuts, contrary to common engineering practice of lowering slope angles for unstable areas. Some slides are exacerbated by larger exposed surfaces
- Locate additional satisfactory material borrow sources (granular)
- Continuous training/instruction for contract staff and labor force
- Avoiding deep culverts, relocating new ones and plugging old culverts
- Erosion control – adding “Trinchos” and stepped Grouted Cobble Flumes
- Continuous maintenance of drainage ditches & inlets during construction activities – Prevent water ponding



Contact Information

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678-354-0310

U.S. Army Corps of Engineers

Savannah District

Environmental & Matereials Unit

Marietta, Goergia

michael.p.wielputz@sas02.usace.army.mil

Dewey Dam
Seismic Assessment

2005 Tri-Service Infrastructure Systems Conference

St. Louis, MO

Huntington District

Fuller Mossbarger Scott & May

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Site Location

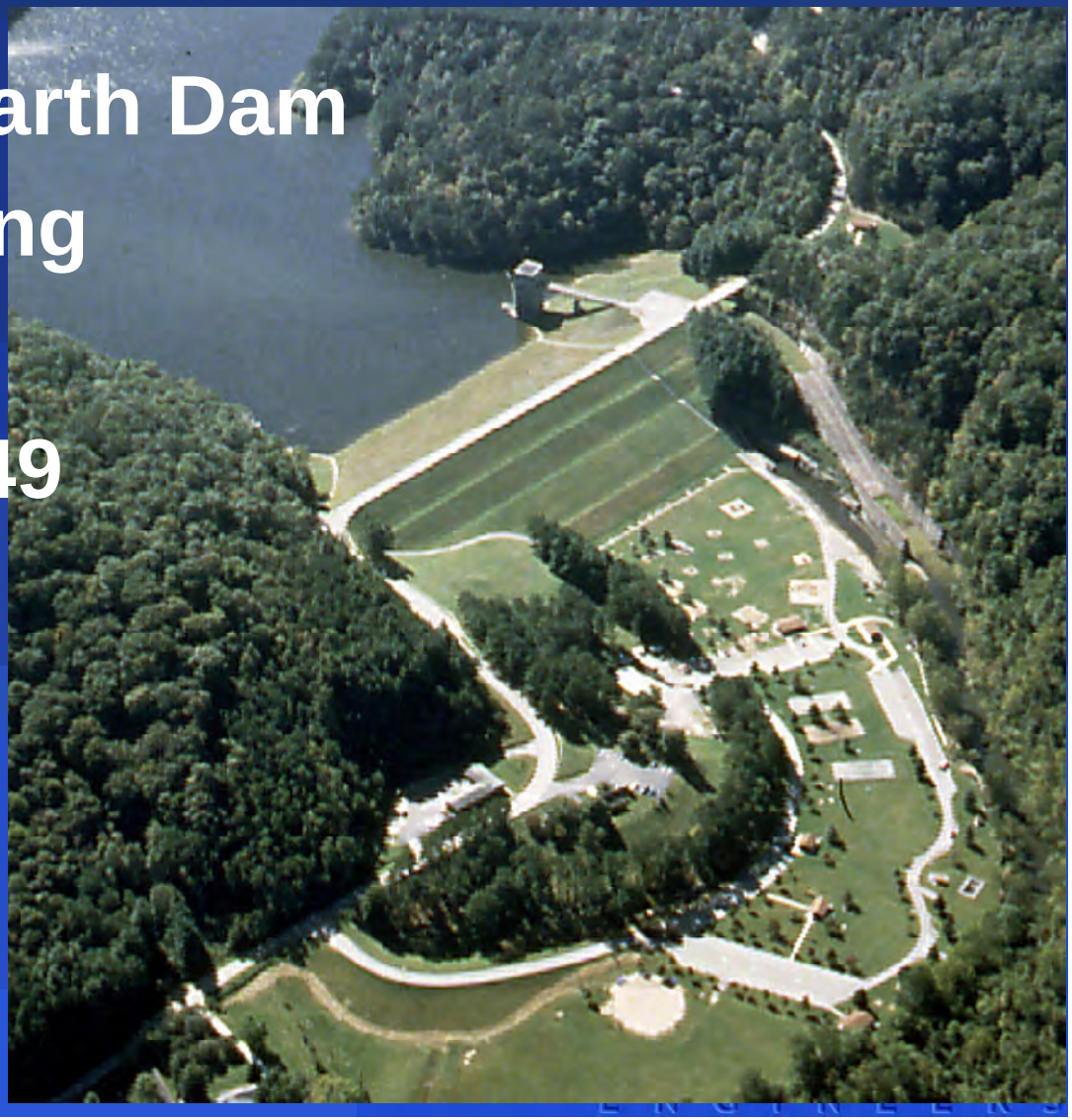


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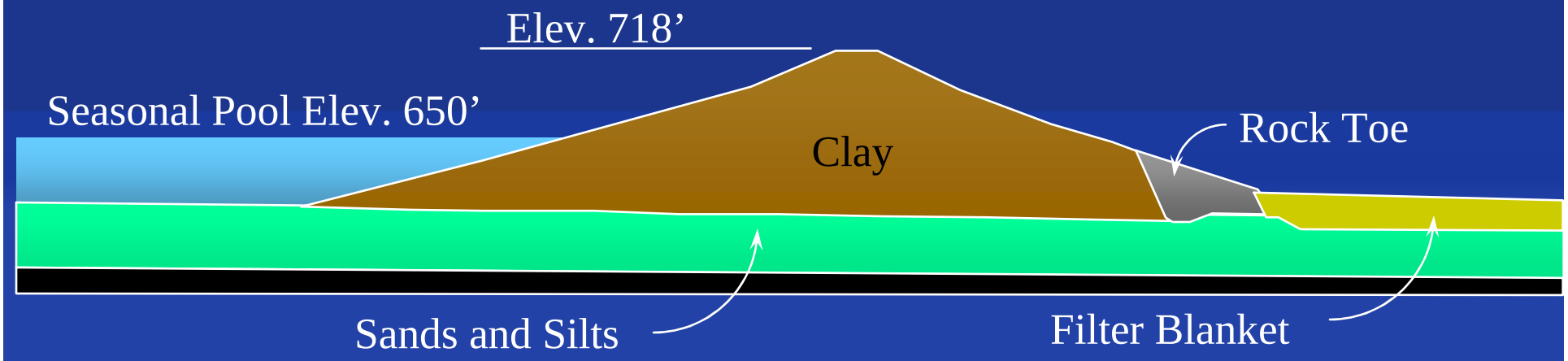
Project Description

- **Homogeneous Earth Dam**
- **118' Tall; 913' Long**
- **On John's Creek**
- **Completed in 1949**



Project Description

Typical Embankment Section



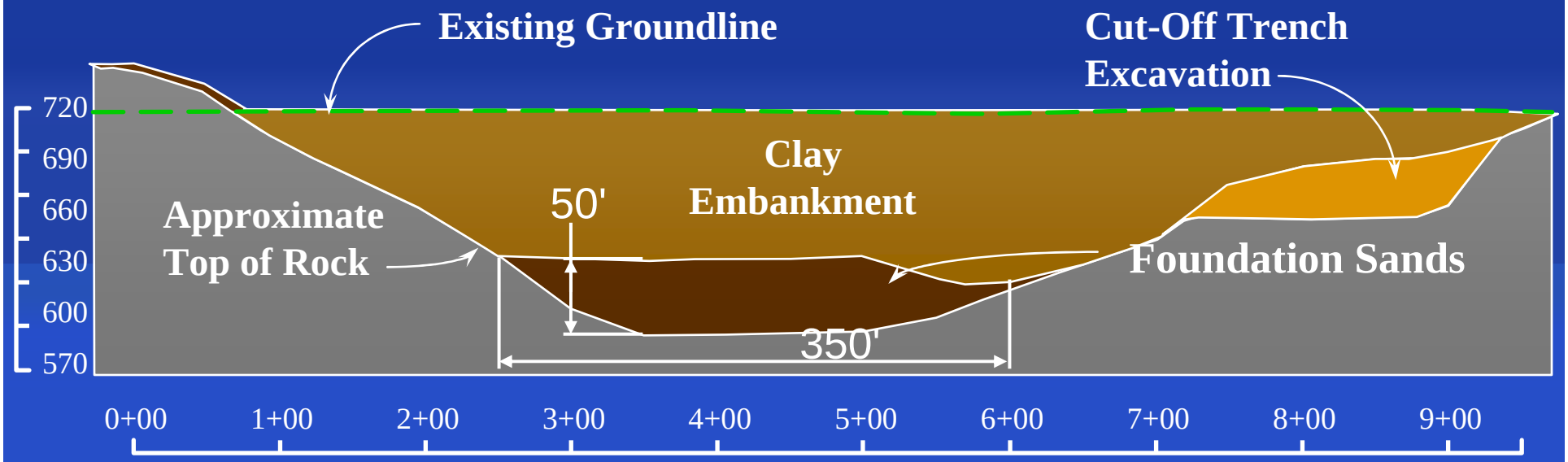
Station 3+50

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Project Description

Profile Along Dam Centerline



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Seismic Assessment

- Intermediate Seismic Assessment 1995
- Feature Design Memorandum 1997
- SPT & CPT Tests 1996-98
- Seismic Assessment Report 1998



View of Downstream Area

1998 Seismic Analysis Report

Conclusions

- Remediation Cost ≅ $13 Million

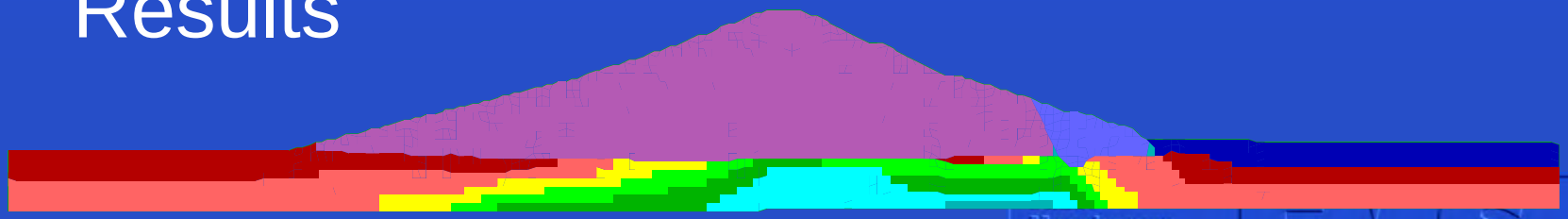
Recommendations

- Site Specific Seismic Study (2000)
- Additional Field Work (1999)
- Hydro-fracture Potential (1999)
- Specific Design Criteria (pending)

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TARA – FLAC Comparison

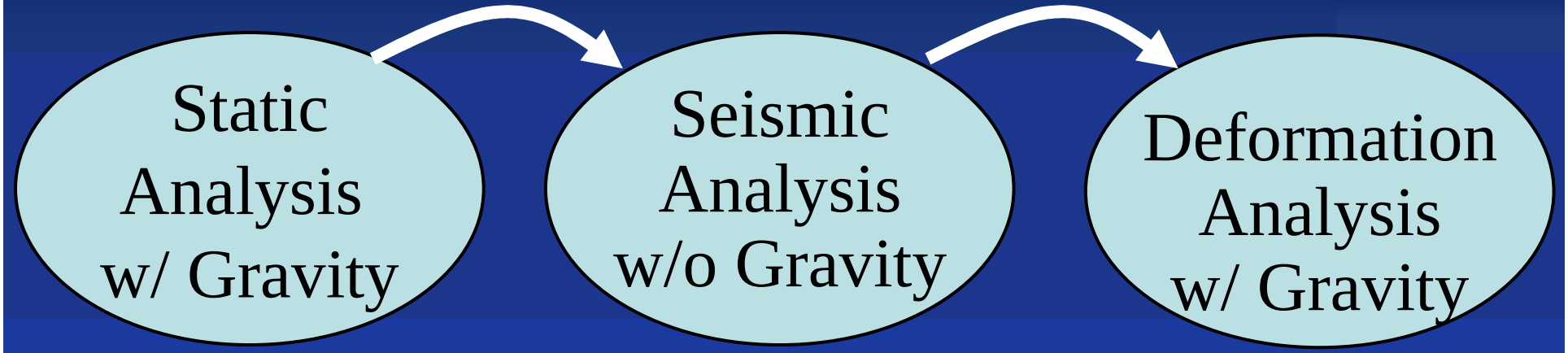
- Incorporated the TARA model into FLAC
- Obtained Parameters used by Dr. Finn
- Completed 1998 TARA Analysis using FLAC
- Dr. Finn Reviewed & Concurred with Results



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TARA – FLAC Comparison

TARA



FLAC

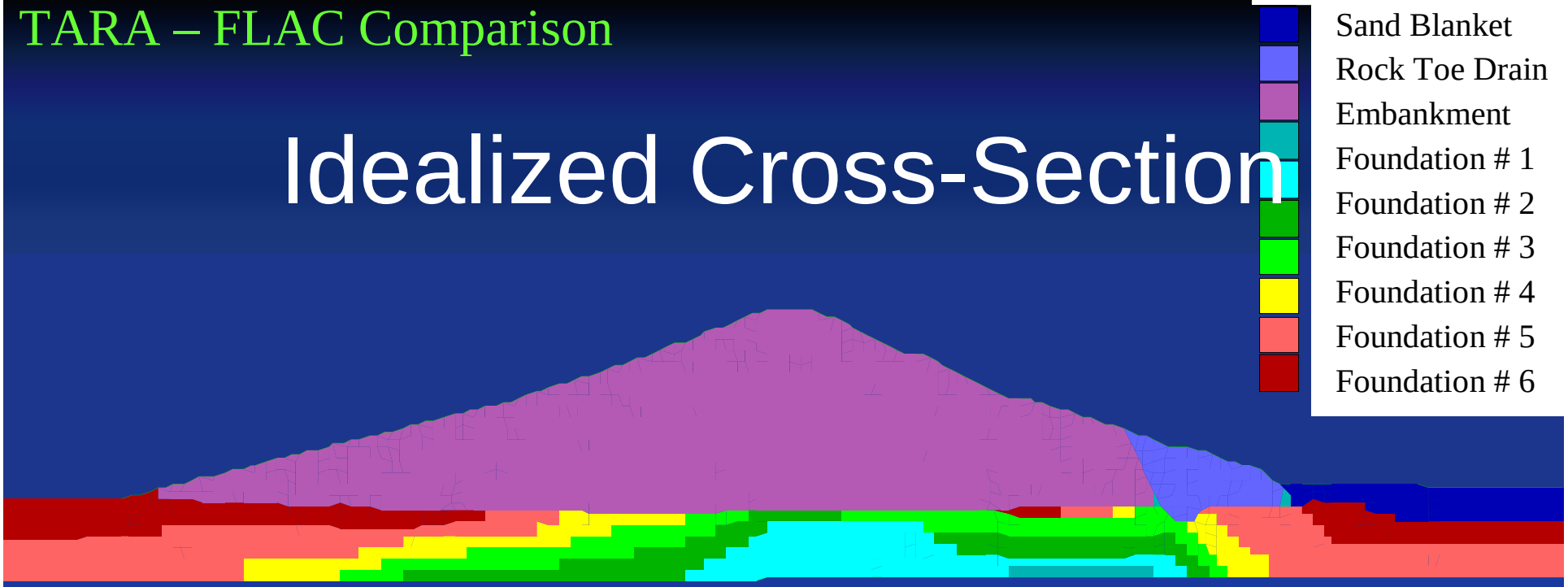
All Combined w/ Gravity

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TARA – FLAC Comparison

Idealized Cross-Section

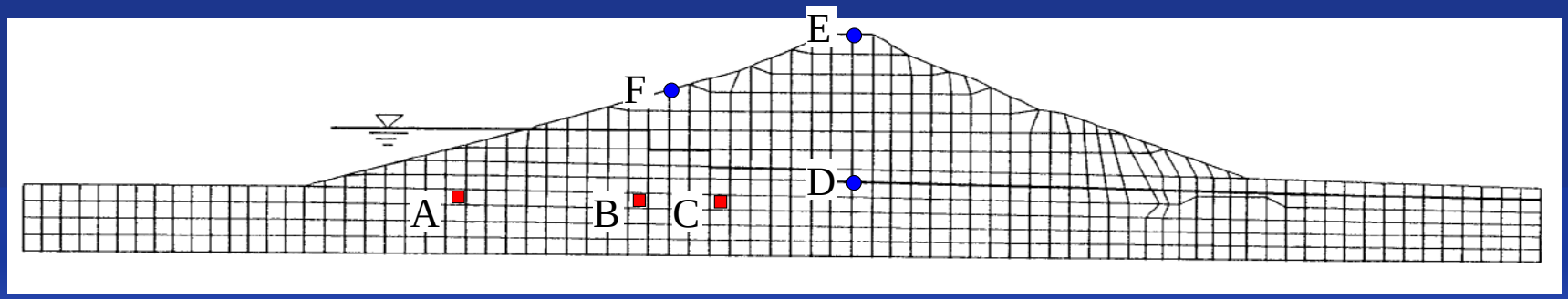


Region	Unit Weights		Undrained Strength		Drained Strength		Clean Sand	Residual Strength	Shear Modulus	PWP[1] Model
	γ_m (pcf)	γ_{sat} (pcf)	ϕ (deg)	c (ksf)	ϕ' (deg)	c' (ksf)	$(N_1)_{60}$	$c_{residual}$ (ksf)	K_{2max}	K_r
Embankment	127	130	18	2.0	29.0	0.0	--	--	60-80	--
Filter Blanket	--	130	16	1.8	34.0	0.0	--	--	60	--
Toe Drain	110	110	--	--	38.0	0.0	--	--	61	--
Foundation #1	--	133	16	1.8	34.0	0.0	16	0.7	27	0.0366-0.0389
Foundation #2	--	133	16	1.8	34.0	0.0	15	0.6	27	0.0316-0.0323
Foundation #3	--	133	16	1.8	34.0	0.0	14	0.5	27	0.0279-0.0287
Foundation #4	--	128	21	0.6	30.0	0.0	13	0.4	27	0.0043-0.0087
Foundation #5	--	128	21	0.6	30.0	0.0	11	0.3	27	0.0035-0.0071
Foundation #6	--	128	21	0.6	30.0	0.0	9	0.2	27	0.0034-0.0081
Foundation #7	--	128	21	0.6	30.0	0.0	5	0.1	27	0.0027-0.0078

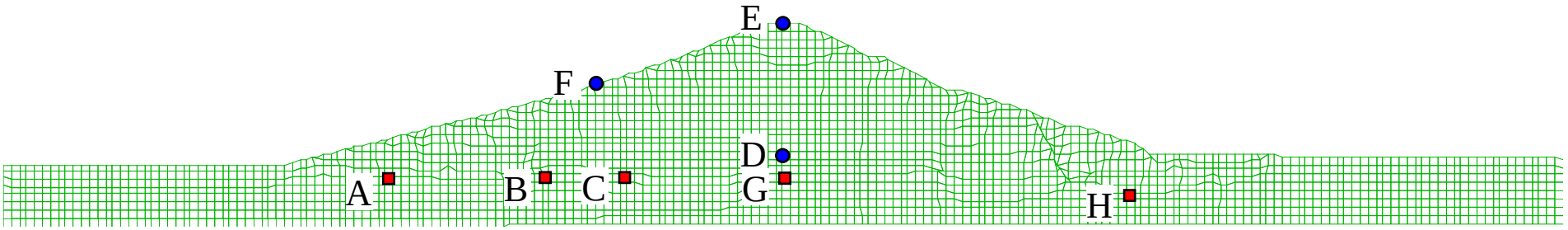
[1] $C_1 = 0.76$; $C_2 = 0.53$

TARA – FLAC Comparison

TARA



FLAC



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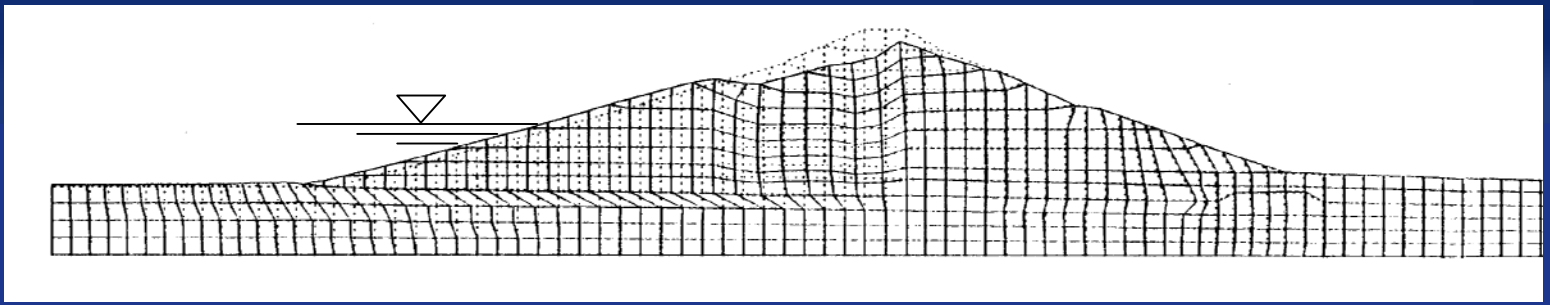
FLAC PWP Calibration

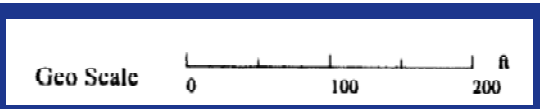
- FLAC Modeling Calibrated with Time History and ENC.
- Results for both analyses shown for comparison.

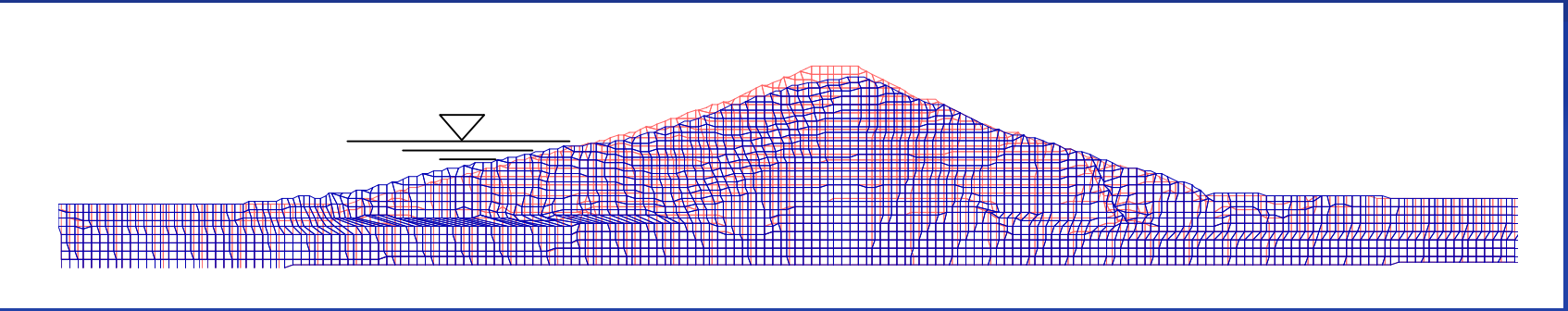
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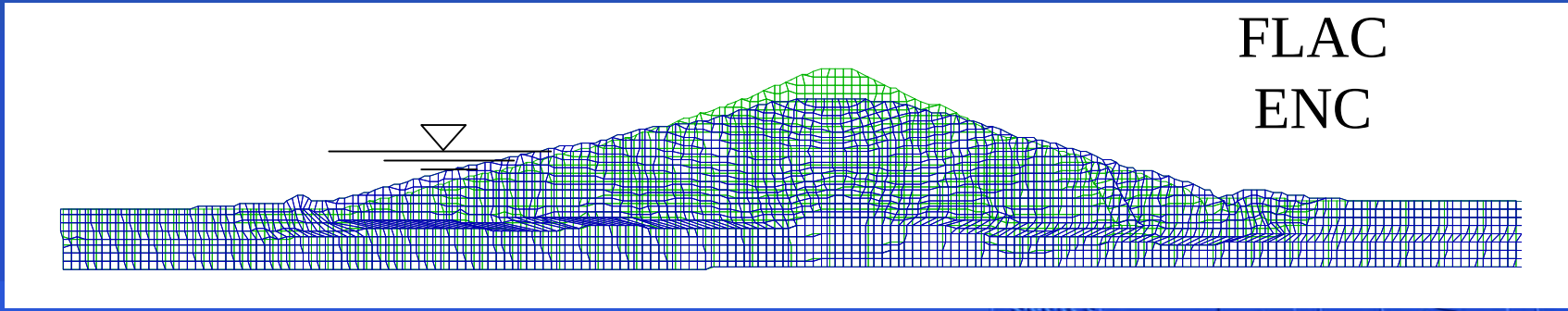
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TARA – FLAC Comparison

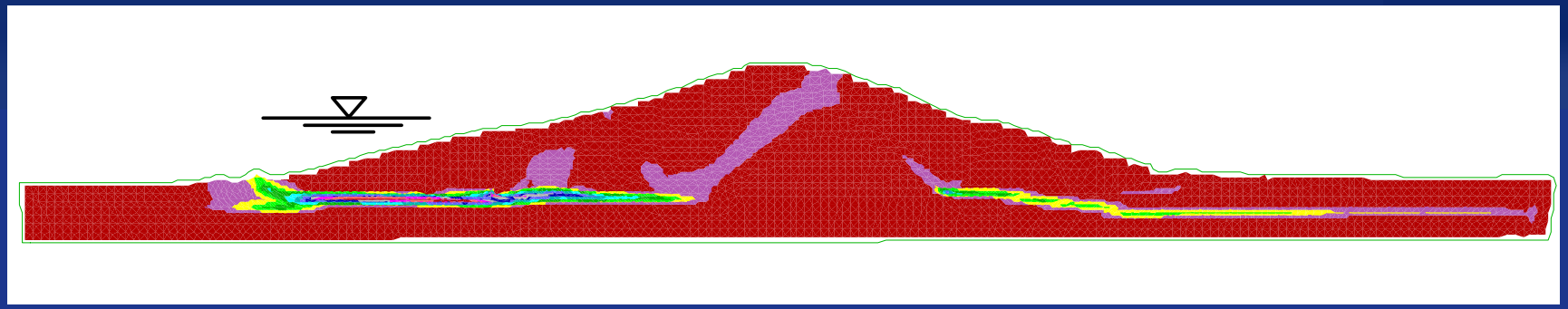


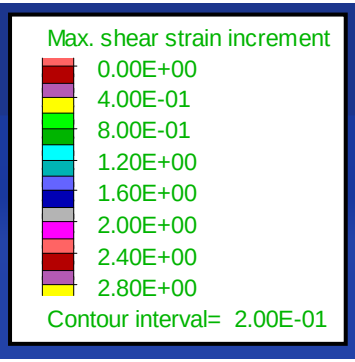




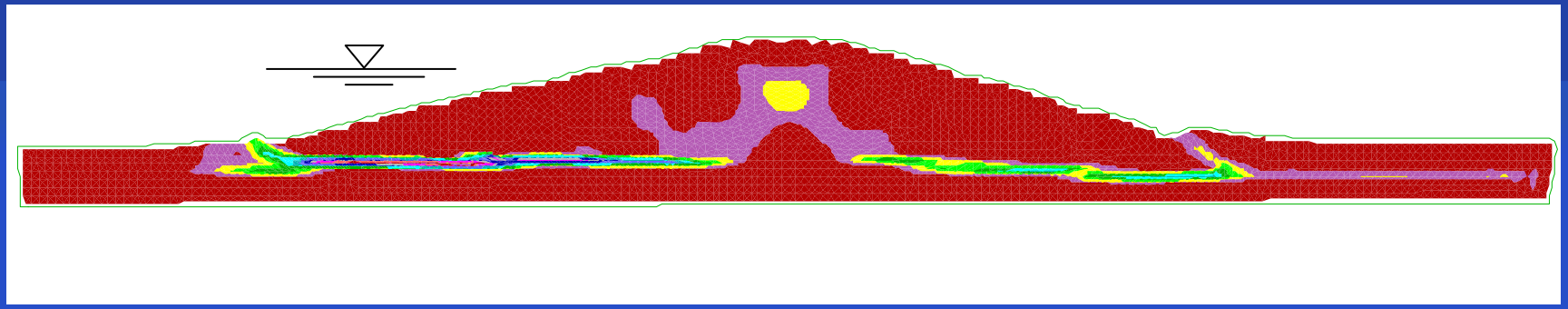


TARA – FLAC Comparison





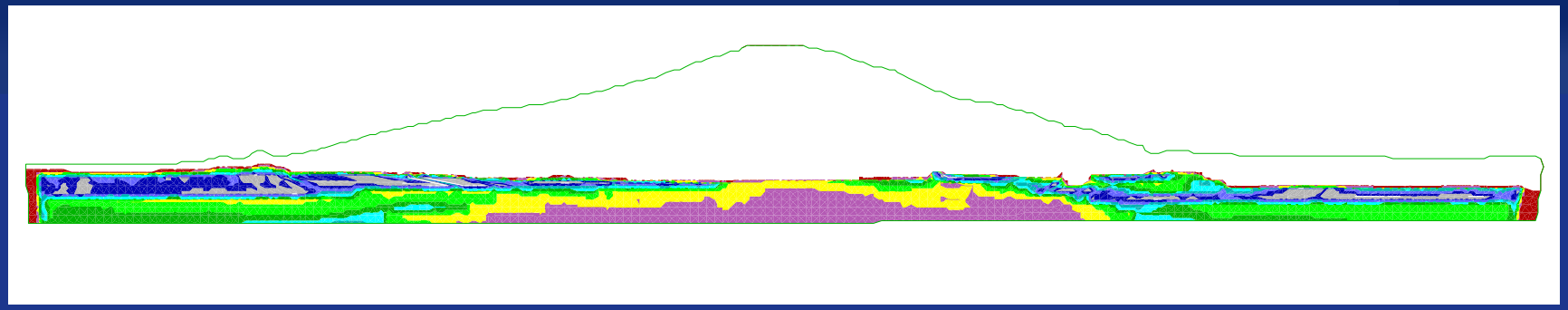
Shear Strain Contours

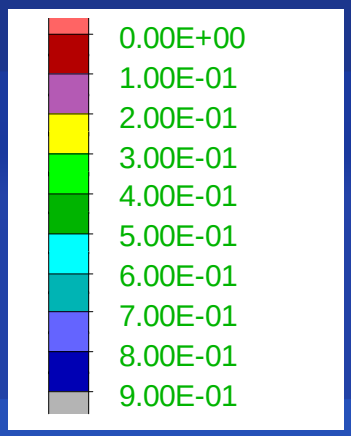


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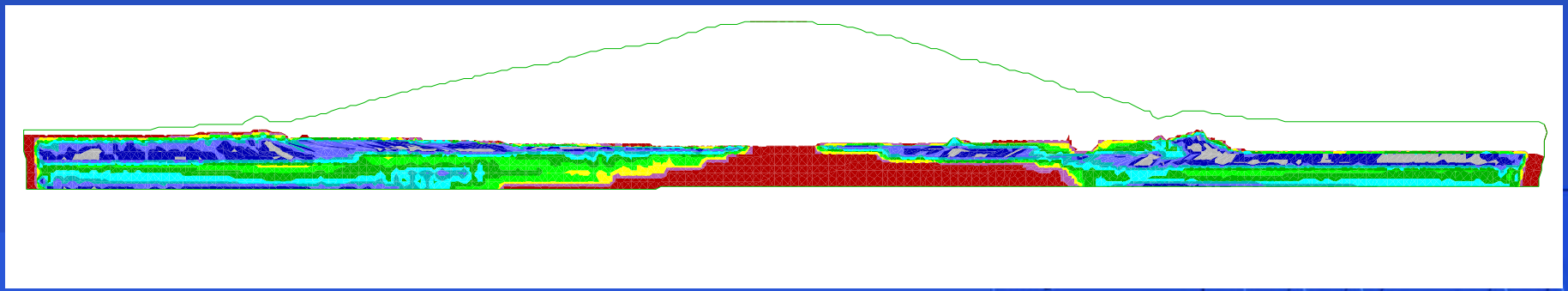
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TARA – FLAC Comparison





Excess PWP Ratio Contours



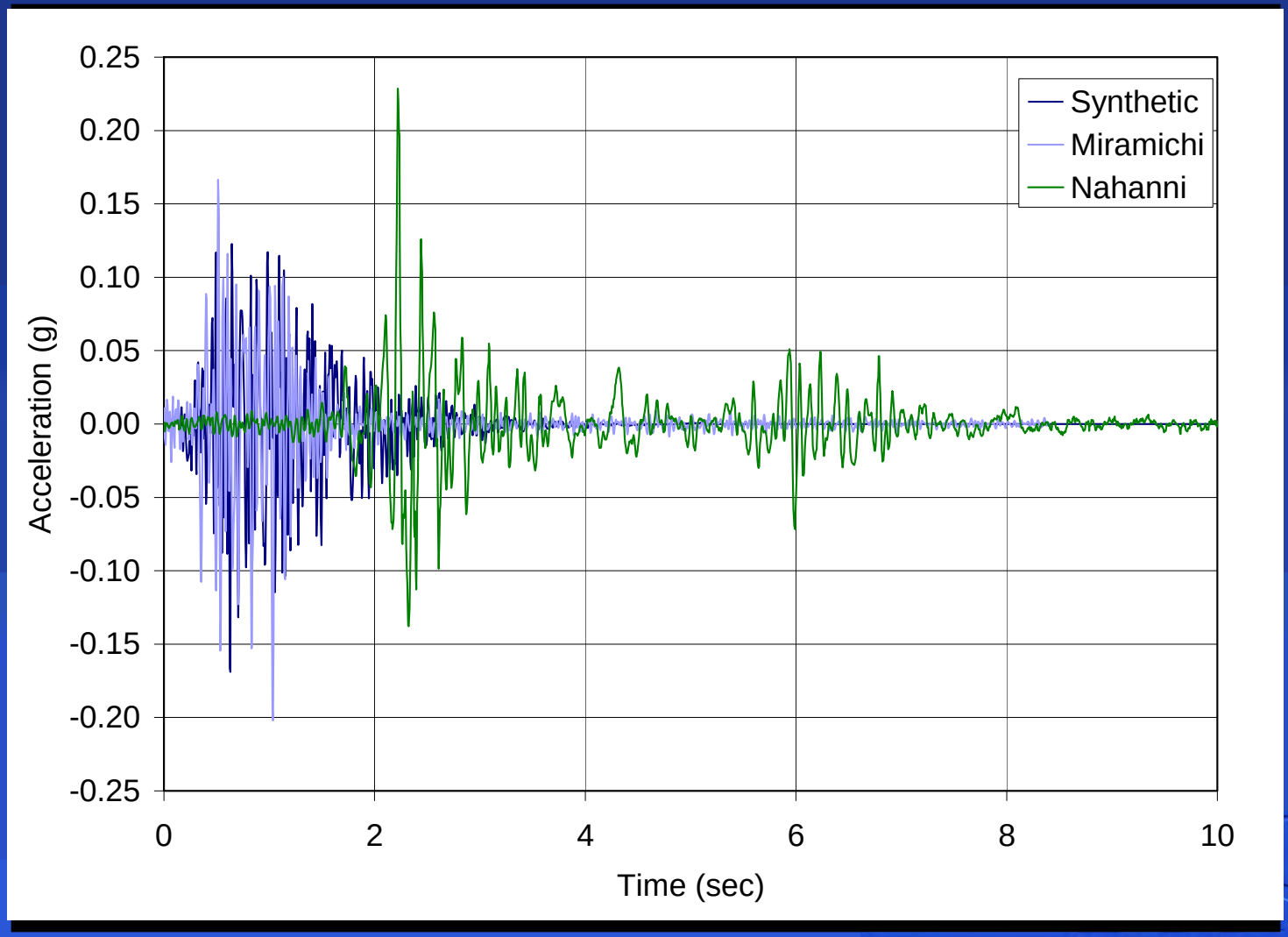
Existing Condition Analyses

- New Design Earthquake, M_w = 5.5, PGA=0.17
- Three Time Histories
- Improved Characterization of Foundation
- Undrained Strengths in Embankment
- Review and Concurrence by Dr. Finn

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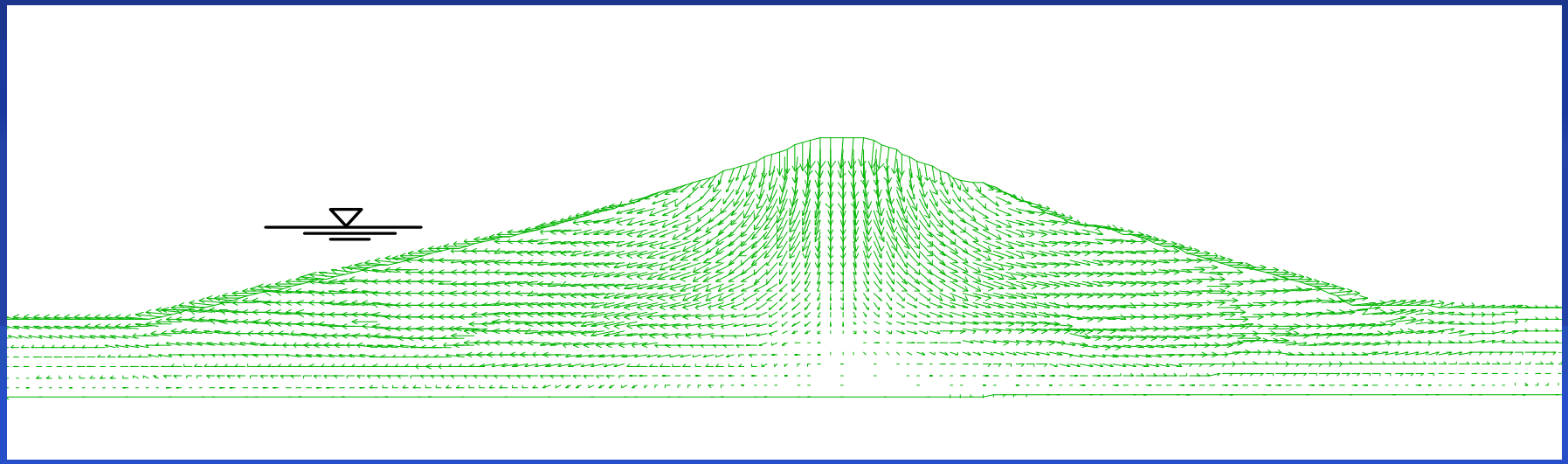
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Design Time Histories



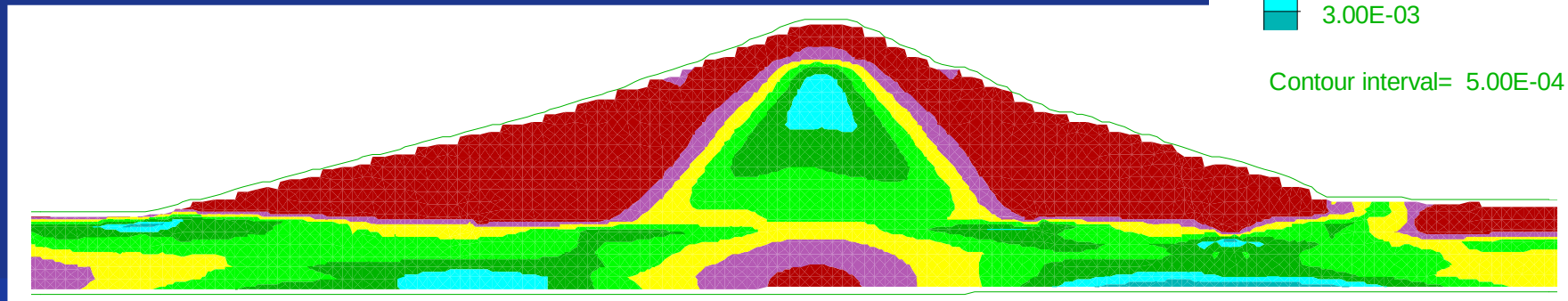
Deformations

Maximum Displacement 0.25 feet



Existing Condition Analyses

Shear Strain



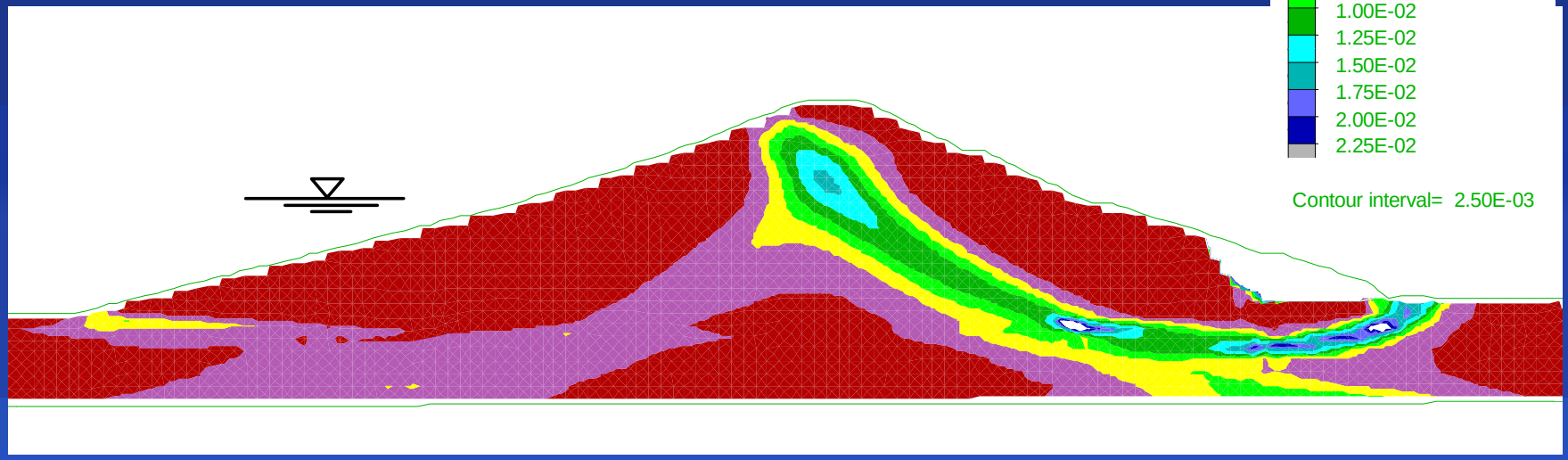
Excess PWP Ratio



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Limit Equilibrium



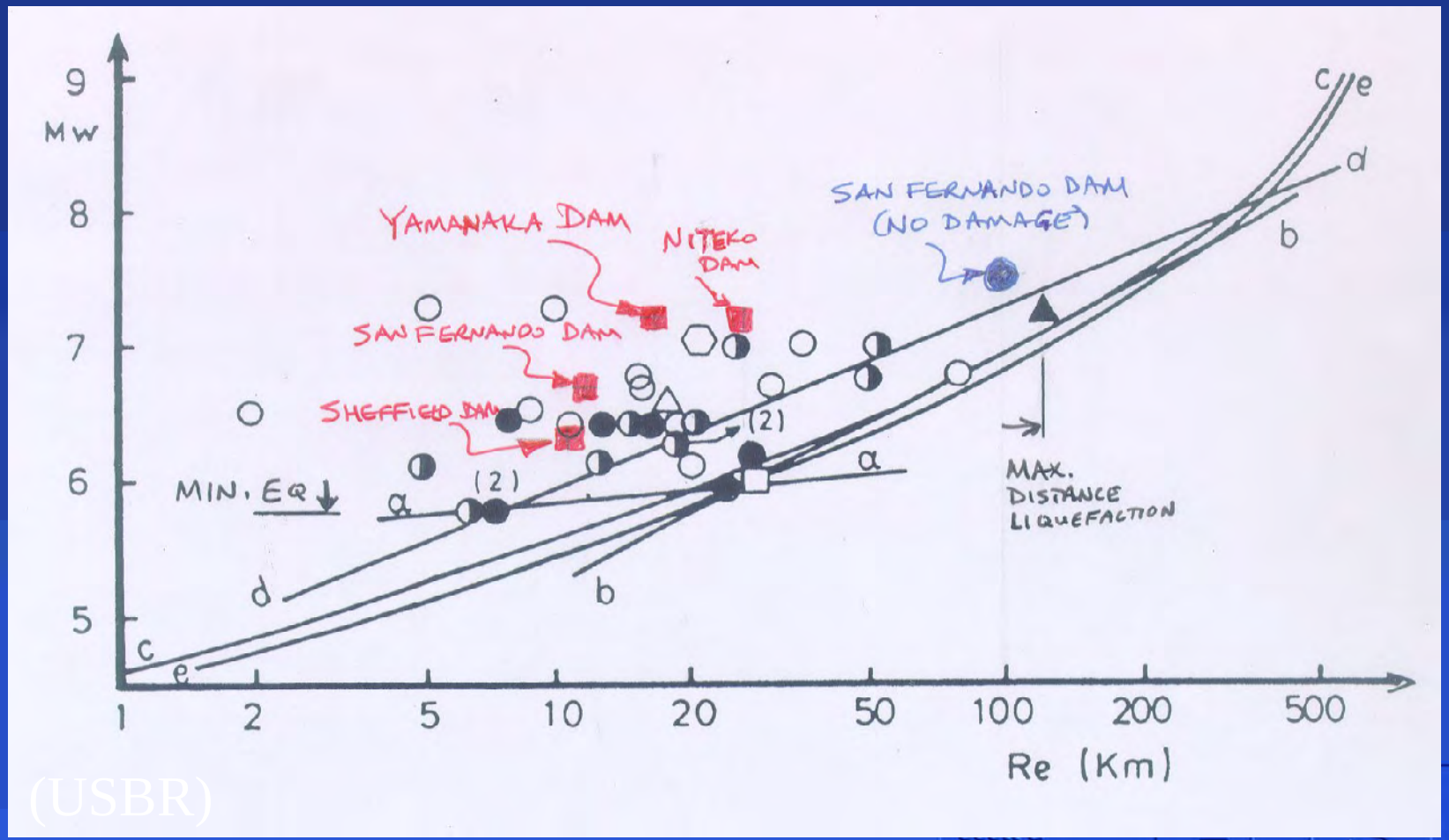
Post Earthquake SF = 1.6

1998 TARA Analyses for OBE

- OBE M_w = 5.0 w/ PGA=0.09g
- New Design MCE M_w = 5.5 w/ PGA = 0.17g
- TARA OBE used M_w = 5.5 w/ PGA = 0.09g
  - System Stable w/ Excess PWP < 13%
- FLAC New MCE
  - System Stable w/ Excess PWP < 25%

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Distance and Magnitude



(USBR)

Summary

- TARA model incorporated into FLAC
- FLAC analyses compare well with TARA
- New existing condition analyses indicate a stable dam because:
  - Reduced earthquake magnitude
  - Use of undrained strengths in embankment
  - Improved foundation characterization
- Dr. Finn reviewed and concurred with results.

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Recommendations

- Remediation of Dewey Dam unwarranted at this time.
- Further assessment warranted only upon advancement of the state-of-the-art.
- Prepare a comprehensive seismic analysis report incorporating the present study.

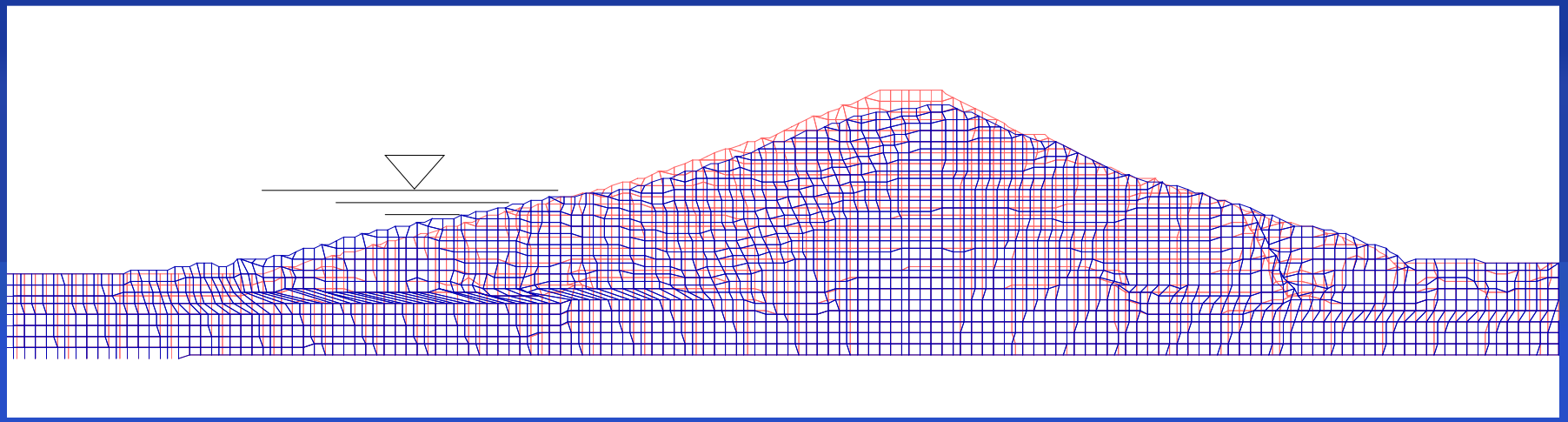
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Huntington District

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Mossbarger
Scott &
May

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Teaming to Provide Practical Solutions to Complex Problems

National Defense Industrial Association
2005 Tri-Service Infrastructure Systems Conference and Exhibition
"Re-Energizing Engineering Excellence"

CHARACTERIZATION OF SOFT CLAY- A CASE STUDY AT CRANEY ISLAND

AARON L. ZDINAK, P.E.
Virginia Geotechnical Services, P.C.
Richmond, Virginia

August 4, 2005

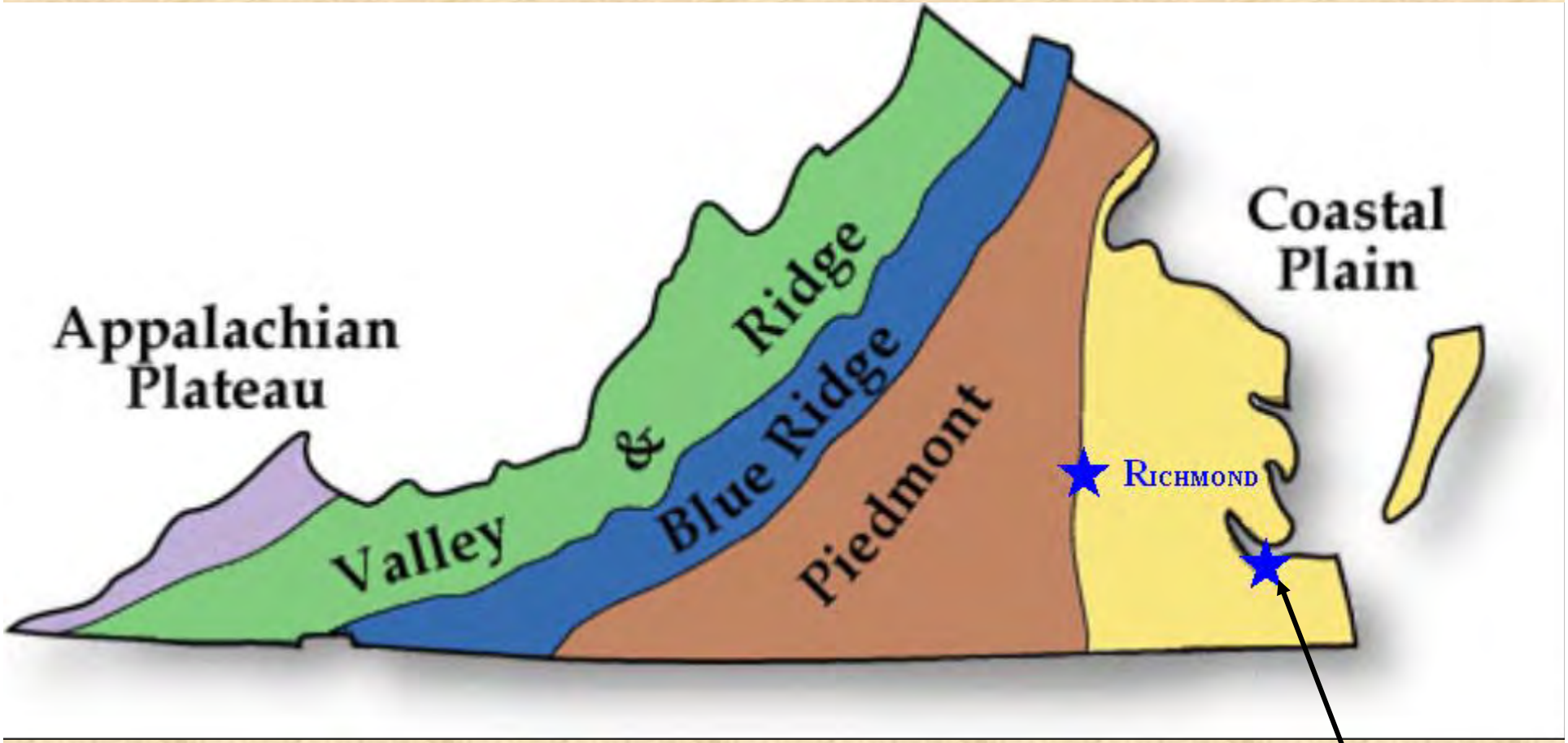
THIS MADE POSSIBLE BY:

- USACE - NORFOLK DISTRICT
  - MATTHEW BYRNE, IRA BROTMAN, DAVID PEZZA, CHERYL FROMME (ALL P.E.s)
    - PROJECT OWNER (COORDINATED FUNDING)
    - PROJECT DEVELOPMENT
- VIRGINIA GEOTECHNICAL SERVICES, P.C.
  - ENTIRE GEOTECHNICAL GROUP (AND A FEW OTHERS)
    - EXECUTION OF SCOPED SERVICES
- DR. J. MICHAEL DUNCAN, P.E.
    - SENIOR TECHNICAL CONSULTANT FOR CHARACTERIZING SOFT SOILS (CHARACTERIZATION TECHNIQUES, INTERPRETATION OF DATA, CONCEPTUAL APPLICATIONS OF ENGINEERING TECHNOLOGY).
- SUBCONSULTANTS
  - FUGRO GEOSCIENCES (SPT/FVS/CPT)
  - INSITU SOIL TESTING, INC. (DMT)
  - GLENN & SADLER (EXPLORATION LOCATIONS/SURVEY)
  - OCEAN SURVEYS, INC. (GEOPHYSICAL SURVEY)
  - COORDINATION WITH NUMEROUS OTHERS

PRESENTATION GUIDE

- INTRODUCTION
  - WHERE IS CRANEY ISLAND?
  - WHAT IS CRANEY ISLAND?
  - PROJECT INFORMATION
- APPROACH TO SUBSURFACE CHARACTERIZATION
  - RESEARCH
  - FIELD EXPLORATIONS
  - LABORATORY TESTING
- RESULTS
  - INTERPRETATION
  - APPLICATIONS
- CONCLUSIONS
- SUMMARY

WHERE IS THIS FACILITY?

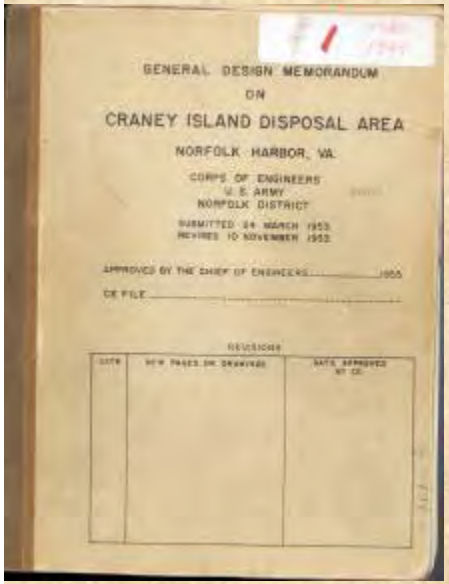


USACE DREDGE MANAGEMENT AREA - CRANEY ISLAND

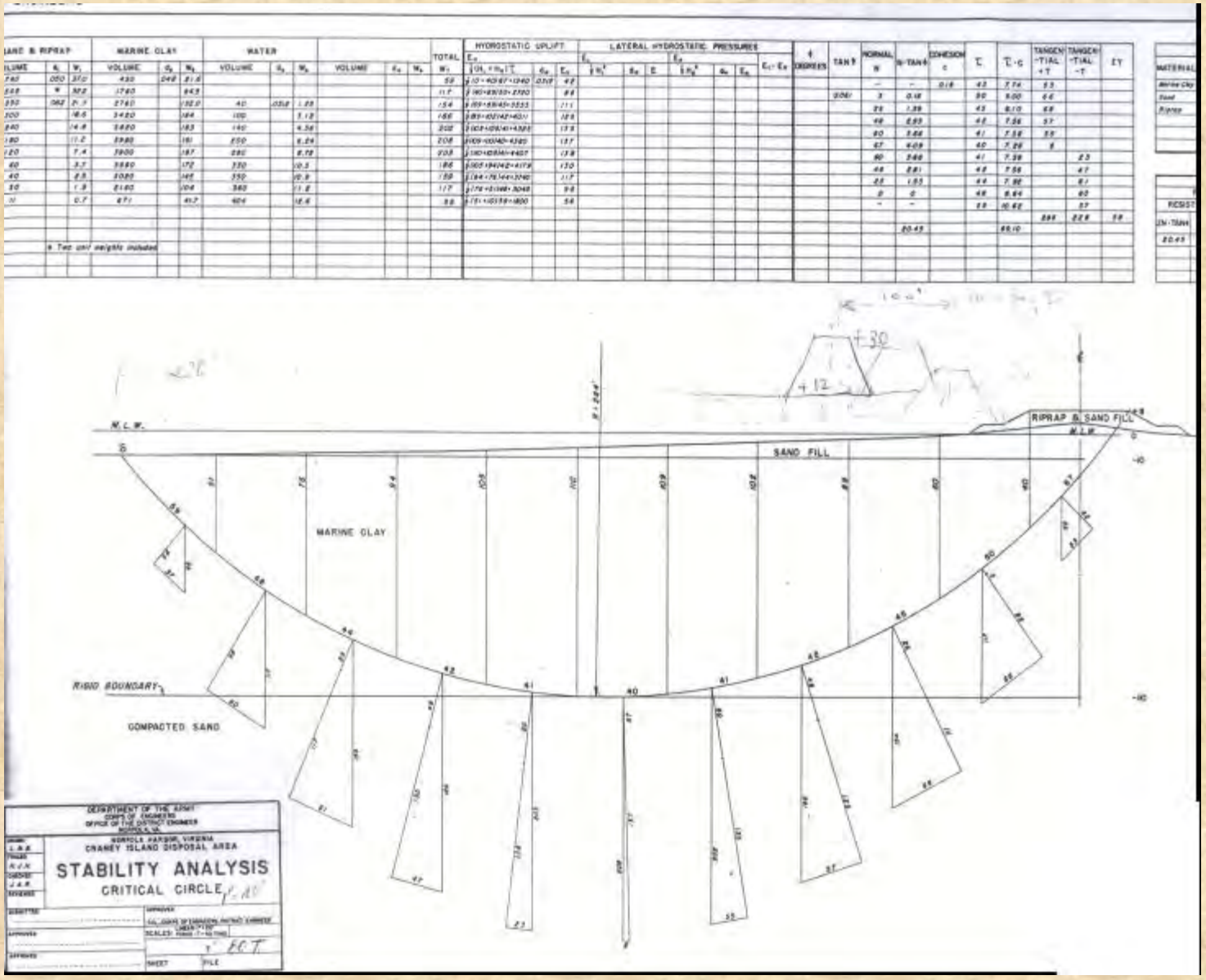
WHAT IS CRANEY ISLAND?

- 2,500 ACRE DREDGE MANAGEMENT FACILITY
- CONSTRUCTION BEGAN IN AUGUST 1954
- COMPLETED IN JANUARY 1957
- MUDLINE AT EL. -10 (MLLW), BERMS EL. 8
- TODAY TOP OF FILL APPROXIMATELY EL. 40

1953 GENERAL DESIGN MEMORANDUM



GENERAL DESIGN MEMORANDUM
ON
CRANEY ISLAND DISPOSAL AREA
NORFOLK HARBOR, VA.
CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT
SUBMITTED 24 MARCH 1953
REVISED 10 NOVEMBER 1953
APPROVED BY THE CHIEF OF ENGINEERS _____ 1955
OCE FILE _____
REVISIONS
DATE | NEW PAGES OR DRAWINGS | DATE APPROVED BY CE



TODAY



SEPTEMBER 28, 1954



DEPARTMENT OF THE ARMY | CORPS OF ENGINEERS | NORFOLK DISTRICT
Island Disposal Area | 28 September 1954 | Serial No. 17182
...tion of West Dike | Contract No. DA-44-110-eng-3116 28 June
view of West Dike. | Contractor : Norfolk Dredging Company
Funds Civil - Construction General

DEPARTMENT OF THE ARMY | CORPS OF ENGINEERS | NORFOLK DISTRICT
y Island Disposal Area | 28 September 1954 | Serial No. 17176
ruction of West Levee | Contract No. DA-44-110-eng-3116 28 June
l view of West Levee, showing | Contractor: Norfolk Dredging Company
ave. | Funds Civil - Construction General

PROJECT SCOPE

- TEAM WITH USACE TO COMPLETE CRANEY ISLAND EASTWARD EXPANSION FEASIBILITY STUDY (2000)
  - PREPARATION OF WORK PLAN TO COMPLETE FEASIBILITY STUDY
  - EXECUTION OF SUBSURFACE EXPLORATION PROGRAM
  - COMPLETION OF LABORATORY TESTING PROGRAM
  - CHARACTERIZATION OF SUBSURFACE CONDITIONS
  - IDENTIFICATION OF APPLICABLE GROUND MODIFICATION TECHNOLOGIES AND CONSTRUCTION TECHNIQUES TO FACILITATE EXPANSION

PROJECT CONSTRAINTS

- EASTWARD EXPANSION OF DREDGE MANAGEMENT FACILITY TO INCREASE PLACEMENT AREA WITH A VERTICAL CONTAINMENT FACE.
- SHORT CONSTRUCTION PERIOD
- TOTAL POST CONSTRUCTION SETTLEMENT < 2”
  - ELASTIC
  - CONSOLIDATION
  - SECONDARY

PROJECT APPROACH

- DEVELOP GEOTECHNICAL ENGINEERING QUESTIONS
  - CAN EMBANKMENT CONSTRUCTION BE ACCOMPLISHED?
  - CAN CONSOLIDATION OCCUR QUICKLY ENOUGH?
  - CAN TOTAL SETTLEMENTS LESS THAN 2” THROUGHOUT LIFE OF THE FACILITY (SECONDARY SETTLEMENT) BE ACHIEVED?
- IDENTIFY INFORMATION TO HELP ANSWER QUESTIONS
  - SHEAR STRENGTH PROFILE
  - CONSOLIDATION PARAMETERS
  - SECONDARY COMPRESSION CHARACTERISTICS
- WHAT CALCULATIONS DOES THE DATA SUPPORT?
  - STABILITY
  - MAGNITUDE AND TIME RATE OF SETTLEMENT
  - SECONDARY COMPRESSION

PROJECT TASKS

- RESEARCH: WHAT HAS BEEN DONE?
  - PREVIOUS STUDIES
  - ANTICIPATED GEOLOGY
- FIELD EXPLORATIONS: WHAT ARE OUR CONDITIONS?
  - SHEAR STRENGTH PROFILE
  - CONSOLIDATION PARAMETERS
  - SECONDARY COMPRESSION CHARACTERISTICS
- LABORATORY TESTING: THE “REAL” ANSWER?
  - SHEAR STRENGTH (UNDRAINED AND DRAINED)
  - SETTLEMENT (PRIMARY AND SECONDARY)
  - BASIC AND INDEX SOIL PROPERTIES
- HOW DOES IT ALL FIT TOGETHER?

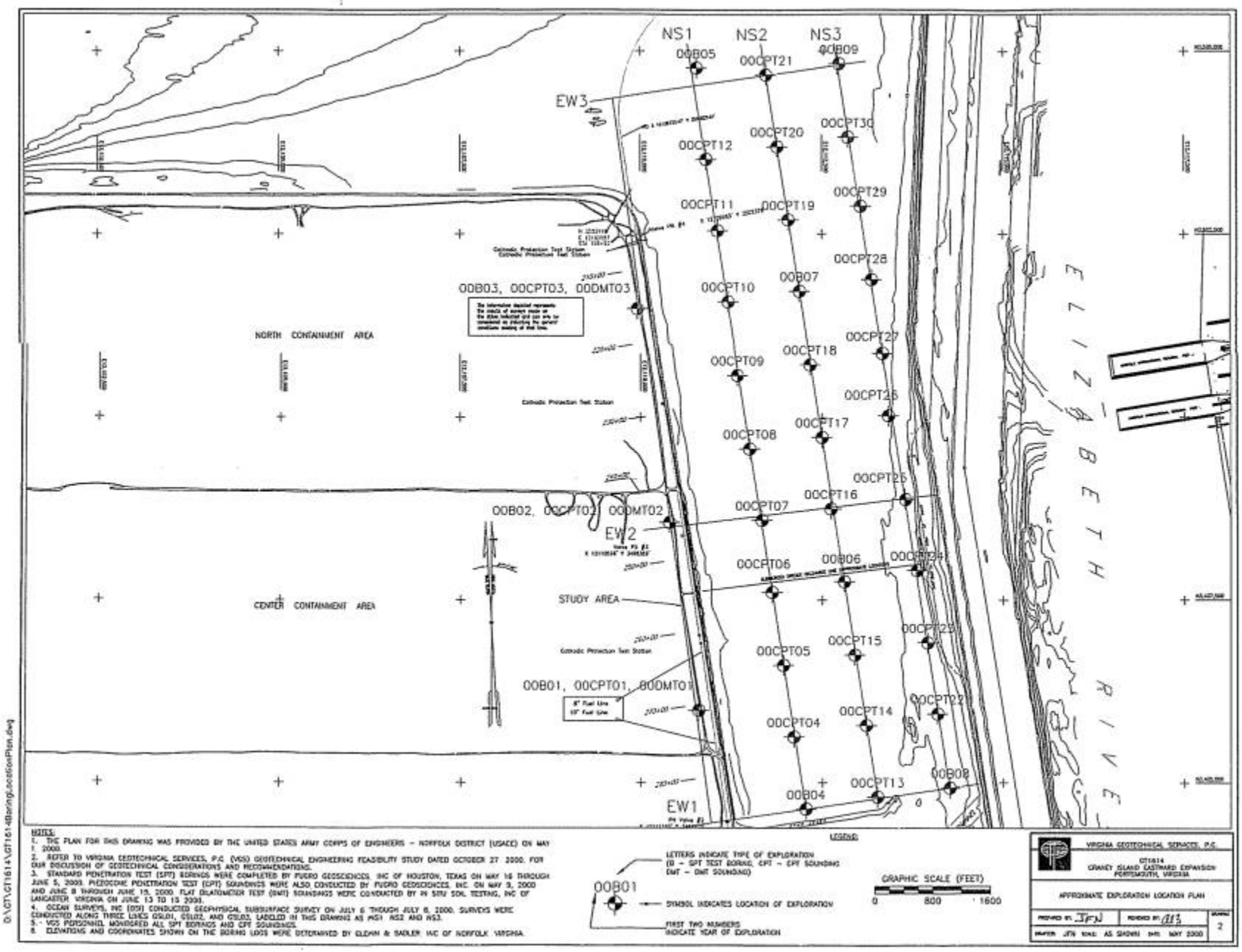
FIELD EXPLORATIONS - GOALS

- STRATIGRAPHY
  - SOFT MARINE SEDIMENTS
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- SAMPLE COLLECTION
  - LIMIT DISTURBANCE
- COLLECT DATA OVERWATER AND OVERLAND

FIELD EXPLORATIONS - TOOLS

- STRATIGRAPHY
  - SPT BORINGS - SAMPLE EVERY 120”
  - DMT SOUNDINGS - SAMPLE EVERY 8”
  - CPT SOUNDINGS - SAMPLE EVERY 0.75”
- SAMPLE COLLECTION
  - SPLIT SPOON SAMPLER
  - PUSHED LINER SAMPLER
  - 5” PISTON TUBE SAMPLER
- IN SITU DATA
  - SPT - BASIC AND INDEX PROPERTIES
  - FVS - MOBILIZED UNDRAINED SHEAR STRENGTH
  - CPT - CORRELATION TO UNDRAINED SHEAR STRENGTH
  - DMT - DRAINED FRICTION ANGLE IN SANDS

EXPLORATION PLAN



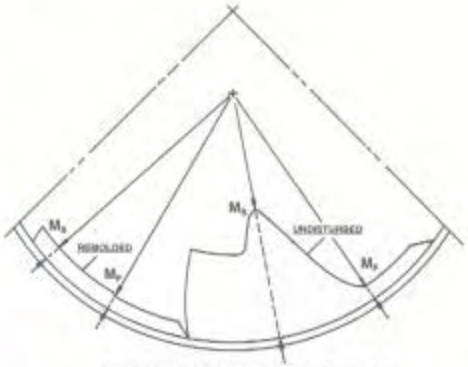
FIELD EQUIPMENT







VANE AND SLIP COUPLING



RECORDING OF VANE BORING CURVE





SPT SUMMARY

- OVERLAND SPT
  - 380 FEET OF DRILLING AT THREE LOCATIONS
  - 11 FIVE-INCH DIAMETER PISTON TUBES
  - NO FVS TESTS
  - 5 DAYS

- OVERWATER SPT
  - 710 FEET OF DRILLING AT SIX LOCATIONS
  - 23 FIVE-INCH DIAMETER TUBES
  - 23 FVS TESTS
  - 13 DAYS DRILLING, 3 DAYS LOST TO WEATHER (16 DAYS)

- **SPT PRODUCTION RATE (SAMPLING EVERY 10')**
  - **OVERLAND = 75 FEET PER DAY**
  - **OVERWATER = 45 FEET PER DAY**

CPT AND DMT SUMMARY

- OVERLAND DMT (SAMPLING EVERY 8”)
  - 370 FEET OF SOUNDING AT THREE LOCATIONS
  - 3 DAYS
  - **RATE = 125 FEET PER DAY** (65% FASTER THAN SPT)

- OVERLAND CPT (SAMPLING EVERY 0.75”)
  - 402 FEET OF SOUNDING AT THREE LOCATIONS
  - 1 DAY
  - **RATE = 400 FEET PER DAY** (430% FASTER THAN SPT)

- OVERWATER CPT (SAMPLING EVERY 0.75”)
  - 2,731 FEET OF SOUNDING AT 27 LOCATIONS
  - 8 DAYS
  - **RATE = 340 FEET PER DAY** (660% FASTER THAN SPT)

NO PHYSICAL SAMPLE RECOVERY

LABORATORY TESTING - GOALS

- CHARACTERIZE STRENGTH AND COMPRESSABILITY PARAMETERS
  - SOFT CLAY
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- CONFIRM RESULTS OF FIELD TESTING
  - UNDRAINED SHEAR STRENGTH RELATIVE TO FVS
- CONFIRM QUALITY OF PREVIOUS STUDY DATA
  - GENERAL DATA TRENDS
  - UNDRAINED SHEAR STRENGTH PROFILE
  - SETTLEMENT PARAMETERS
  - EFFECTIVE STRESS PROFILE UNDER EAST BERM

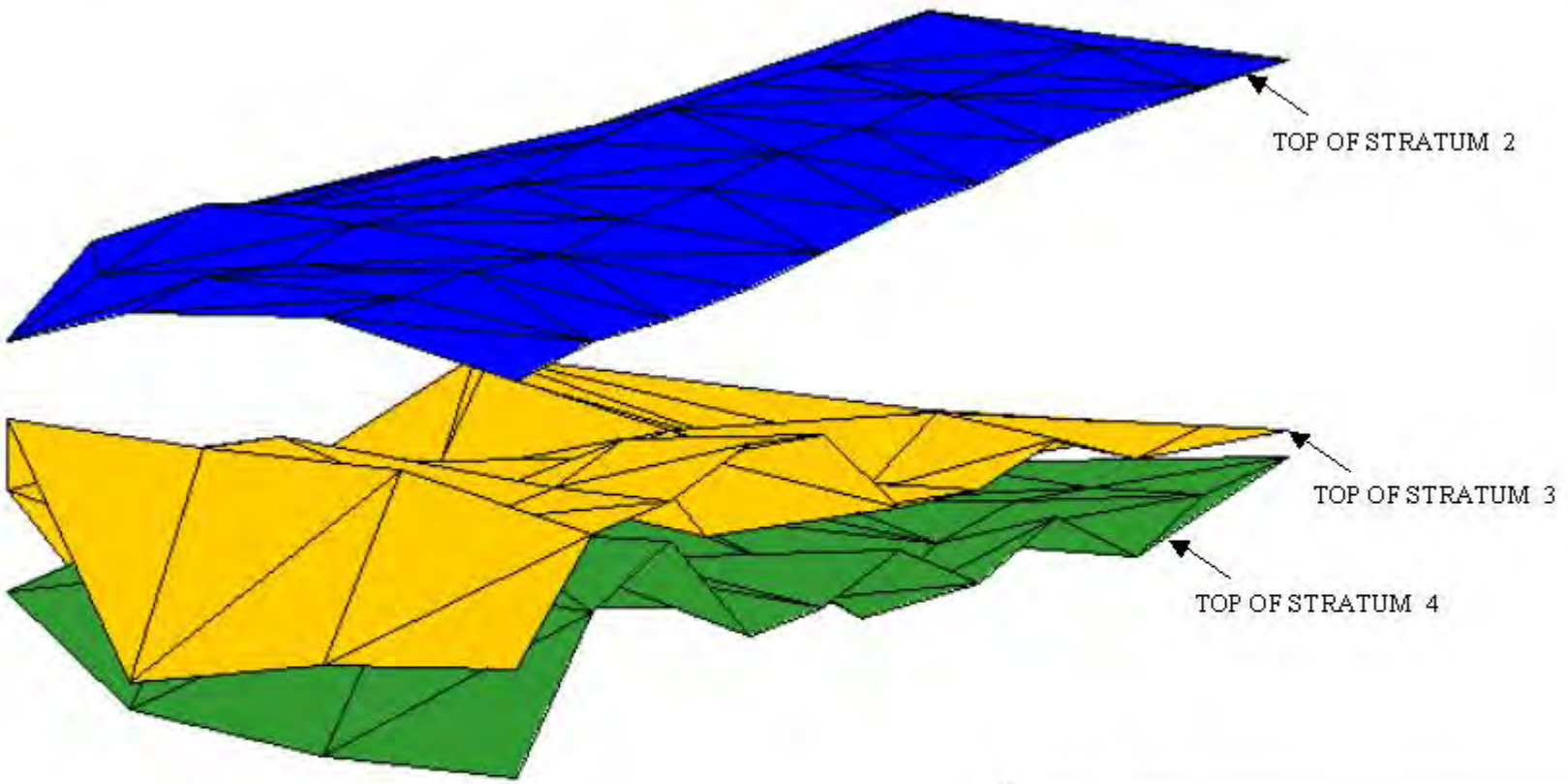
SUMMARY OF LABORATORY TESTING

- BASIC AND INDEX SOIL PROPERTIES
  - MOISTURE CONTENT, LIMITS, GRADATION, ETC.
- SHEAR STRENGTH PARAMETERS
  - CU AND UU TRIAXIAL TESTING, LABORATORY VANE
- COMPRESSABILITY CHARACTERISTICS
  - 1-D CONSOLODATION
- CONCLUSIONS
  - LABORATORY TESTING PROGRAM YIELDED QUALITY DATA
  - DISTURBANCE WAS LIMITED BY COLLECTING LARGE DIAMETER SAMPLES AND TRIMMING
- LABORATORY TESTING LESSONS
  - DON'T SPEND TIME AND MONEY TESTING DISTURBED SAMPLES
  - REQUIRED LABORATORY RETRO-FIT WAS LIMITED
  - QUALITY OF TESTS ARE HIGHLY DEPENDENT ON PROCEDURES

RESULTS

- STRATIGRAPHY
  - SOFT CLAY
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- IN SITU DATA AND LABORATORY DATA
  - UNDRAINED SHEAR STRENGTHS
  - CONSOLIDATION CHARACTERISTICS
- EFFECTIVE STRESS PROFILE (OVERLAND)
  - UNDERCONSOLIDATED
  - CPT AND LABORATORY DATA COME TOGETHER

STRATIGRAPHY: 3-D SURFACE



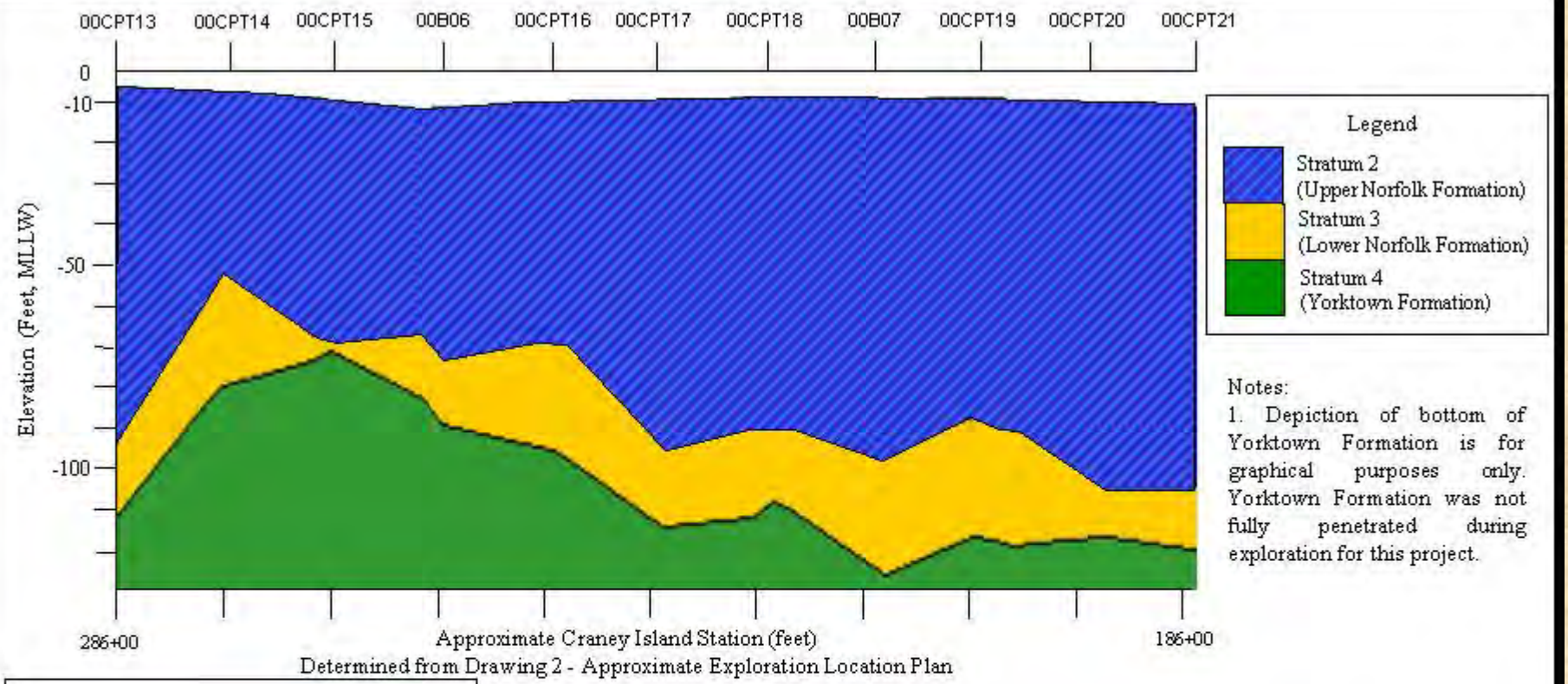
VIRGINIA GEOTECHNICAL SERVICES, P.C.

GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

INTERPRETED 3-DIMENSIONAL SUBSURFACE PROFILE

PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP SCALE: As Shown DATE: Oct 2000		3

STRATIGRAPHY: NORTH-SOUTH LINE



Determined from Drawing 2 - Approximate Exploration Location Plan

Notes:
1. Depiction of bottom of Yorktown Formation is for graphical purposes only. Yorktown Formation was not fully penetrated during exploration for this project.



3-Dimensional profile of interfaces and location of cross-section

Exploration	Northing	Easting
00CPT13	3,494,802	12,113,259
00CPT14	3,495,784	12,113,108
00CPT15	3,496,747	12,112,950
00B06	3,497,749	12,112,808
00CPT16	3,498,743	12,112,623
00CPT17	3,499,724	12,112,502
00CPT18	3,500,716	12,112,338
00B07	3,501,717	12,112,190
00CPT19	3,502,690	12,112,035
00CPT20	3,503,693	12,111,885
00CPT21	3,504,680	12,111,731

Locations surveyed by Glenn & Sadler of Norfolk, Virginia

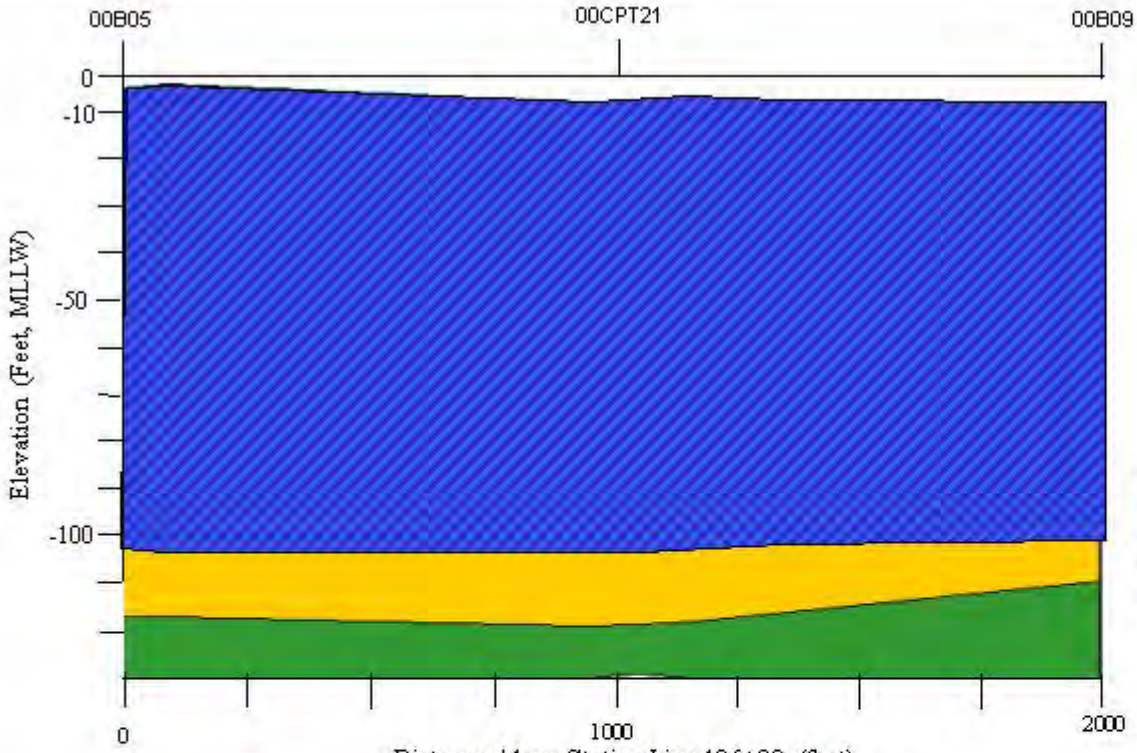
VIRGINIA GEOTECHNICAL SERVICES, P.C.

GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

INTERPRETED SUBSURFACE PROFILE
ALONG NS2

PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP	SCALE: As Shown DATE: Oct 2000	6

STRATIGRAPHY: EAST-WEST LINE



Legend

- Stratum 2 (Upper Norfolk Formation)
- Stratum 3 (Lower Norfolk Formation)
- Stratum 4 (Yorktown Formation)

Notes:
1. Depiction of bottom of Yorktown Formation is for graphical purposes only. Yorktown Formation was not fully penetrated during exploration for this project.



3-Dimensional profile of interfaces and location of cross-section

Exploration	Northing	Easting
00B05	3,504,767	12,110,775
00CPT21	3,504,680	12,111,731
00B09	3,504,828	12,112,742

Locations surveyed by Glenn & Sadler of Norfolk, Virginia

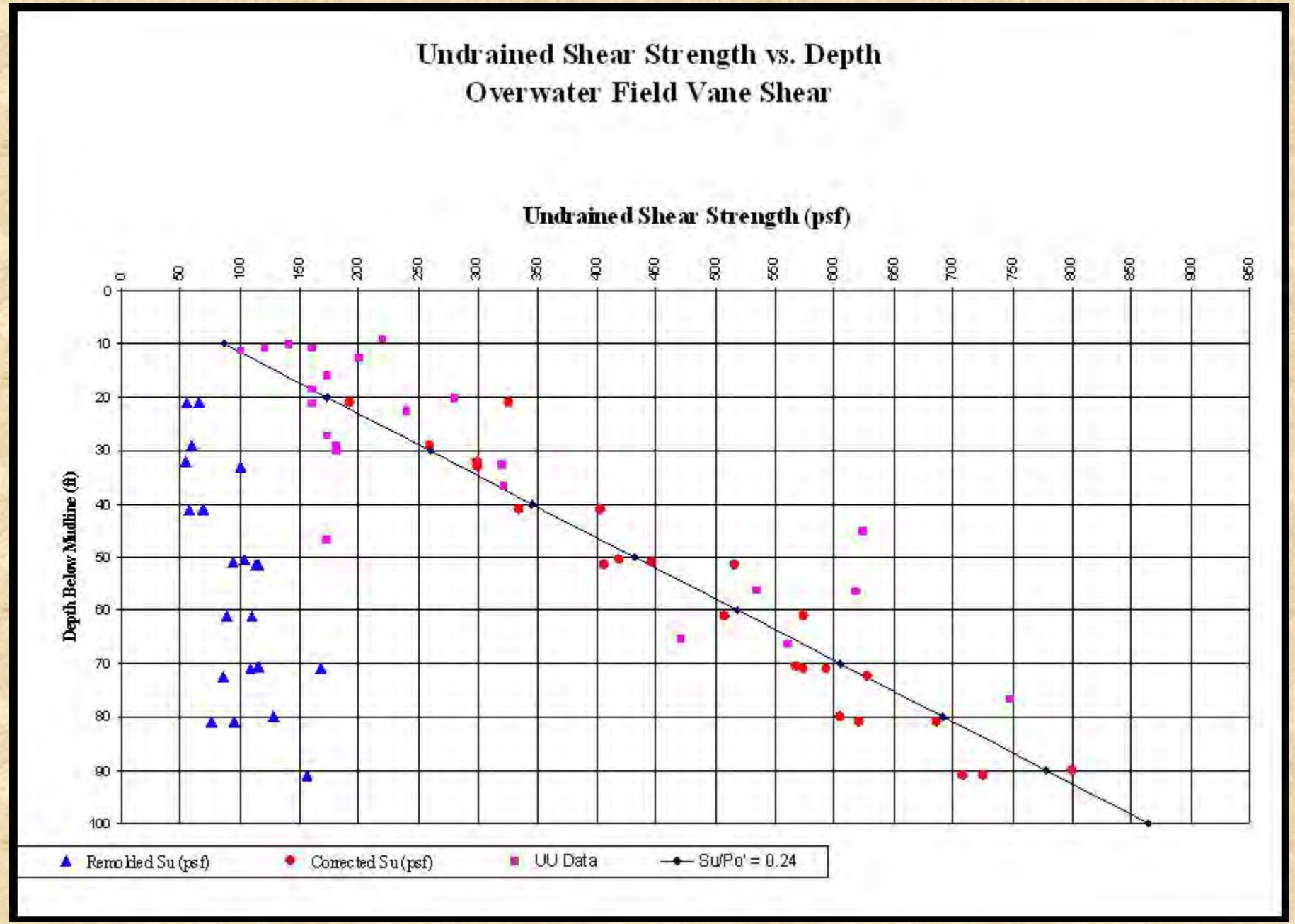
VIRGINIA GEOTECHNICAL SERVICES, P.C.

GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

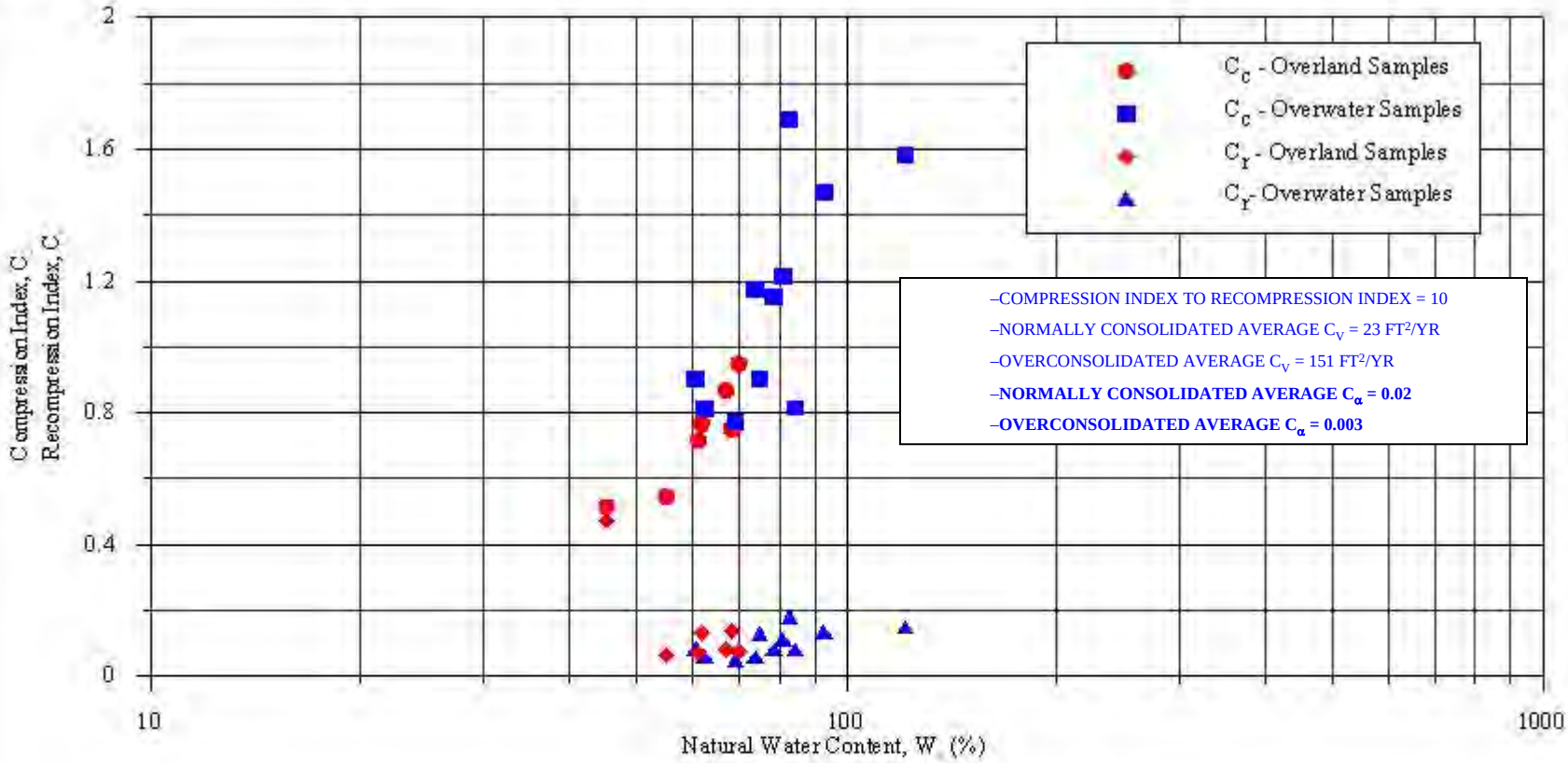
INTERPRETED SUBSURFACE PROFILE ALONG EW3

PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP	SCALE: As Shown DATE: Oct 2000	10

UNDRAINED SHEAR STRENGTH TEST RESULTS



CONSOLIDATION TEST RESULTS



NOTES:
1. C_c and C_r determined from laboratory consolidation tests.
2. $C_c = (1+e_o)CR$, $C_r = (1+e_o)RR$
   where e_o = Initial Void Ratio, CR = Compression Ratio
   and RR = Recompression Ratio

VIRGINIA GEOTECHNICAL SERVICES, P.C.

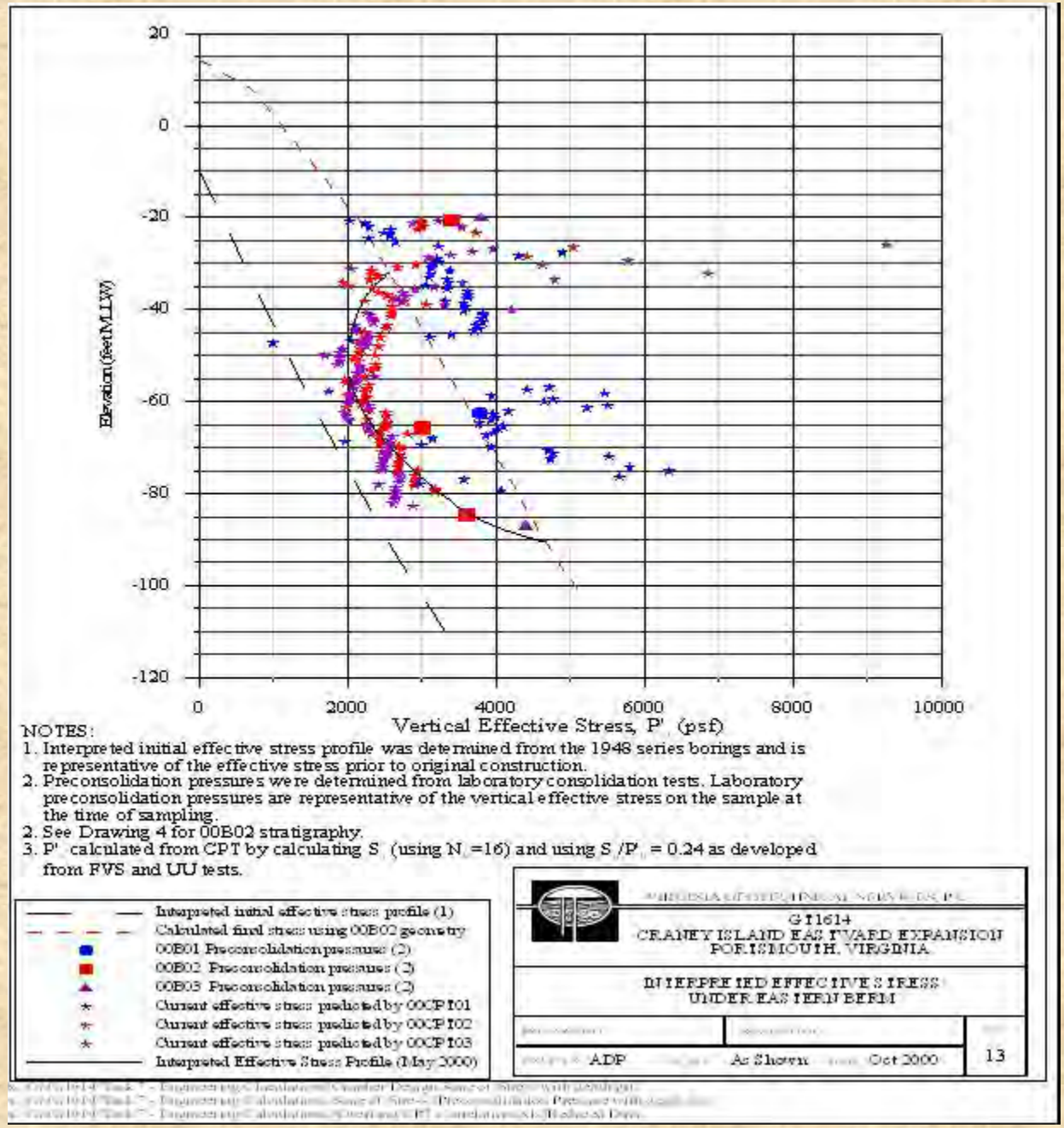
GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

C_c & C_r vs. W_n

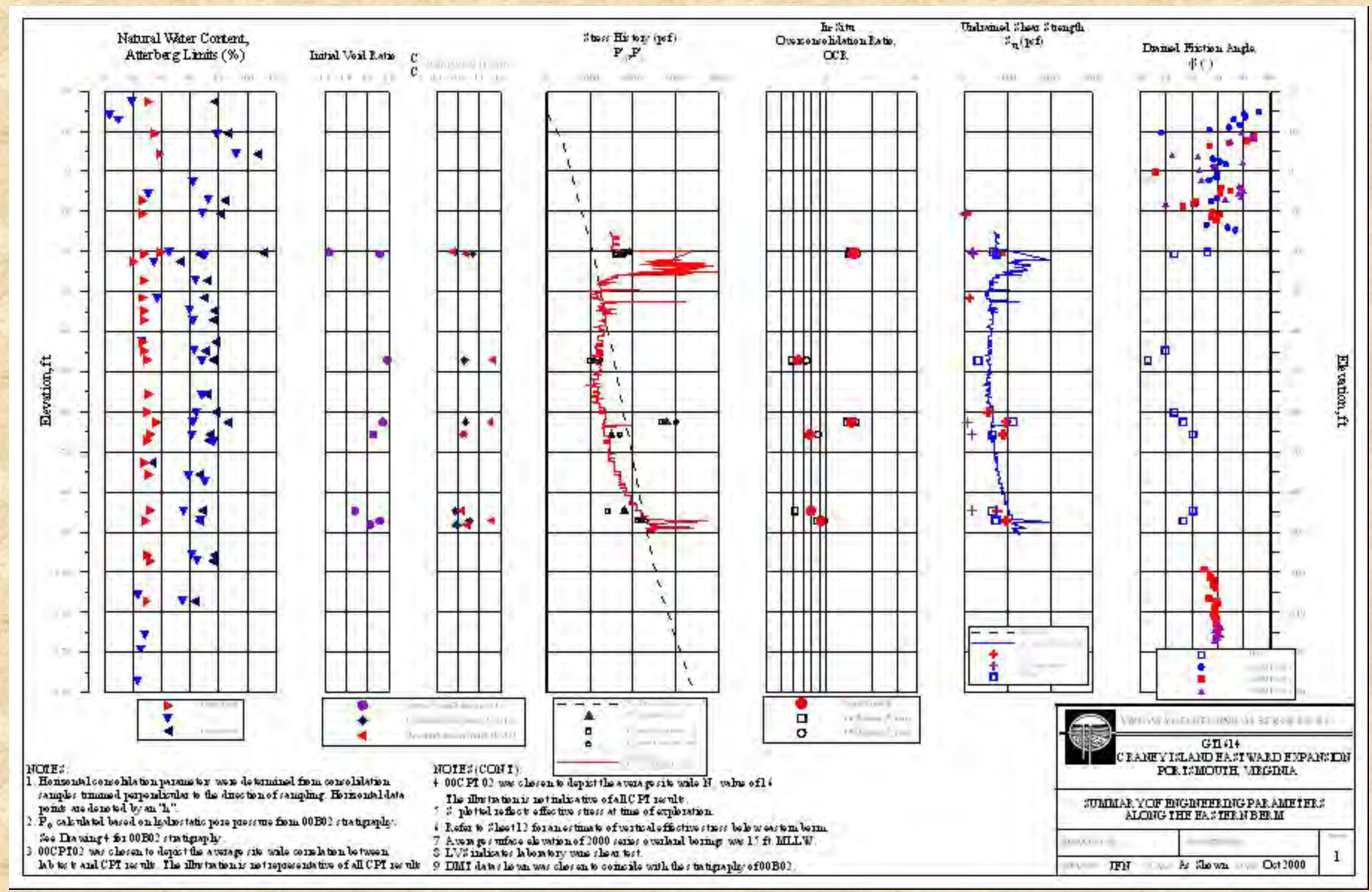
JFN	As Shown	Oct 2000	7

x:\Gt\Gt1614\Task 7 - Engineering Calculations\Grapher\Cr,Cc vs wn.grf
x:\Gt\Gt1614\Task 7 - Engineering Calculations\[Consolidation Summary.xls]Consol Summary (Overland)

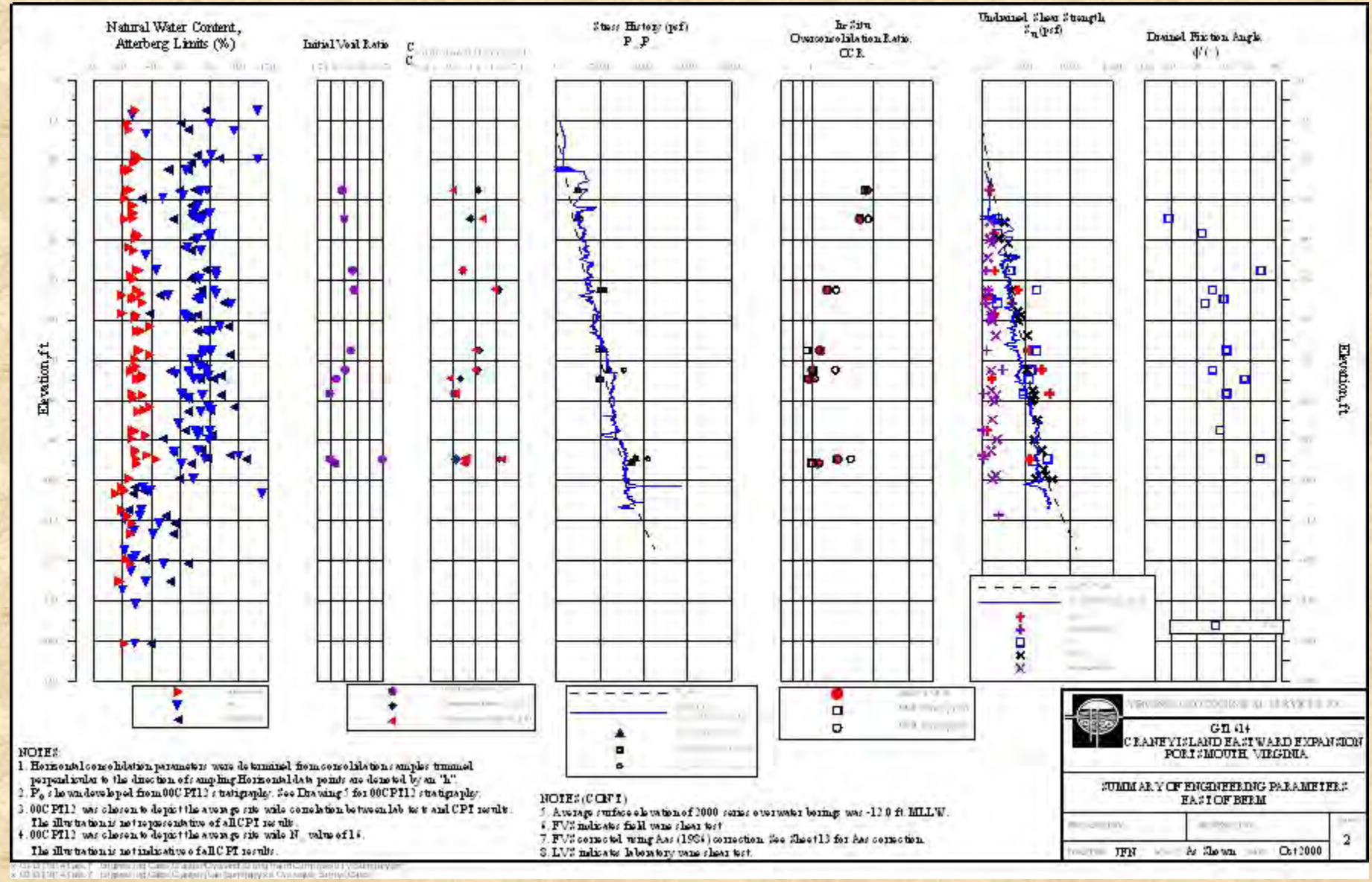
EFFECTIVE STRESS PROFILE UNDER EAST BERM



SUMMARY OF OVERLAND ENGINEERING PARAMETERS



SUMMARY OF OVERWATER ENGINEERING PARAMETERS

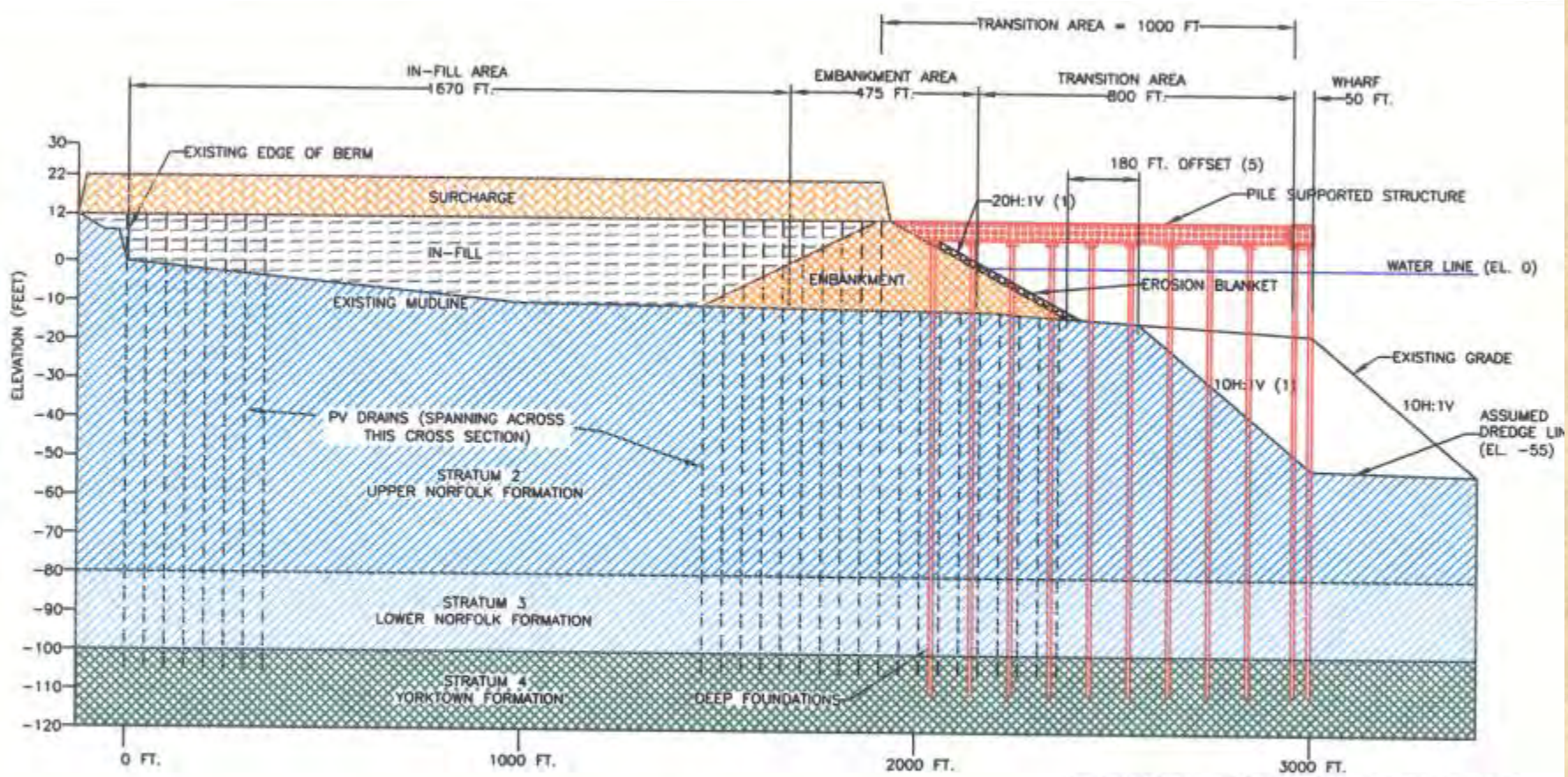


APPLICATIONS - WHAT DOES IT ALL MEAN?

- QUESTIONS
  - CAN EMBANKMENT CONSTRUCTION BE ACCOMPLISHED?
  - CAN CONSOLIDATION OCCUR QUICKLY ENOUGH?
  - CAN TOTAL SETTLEMENTS LESS THAN 2” THROUGHOUT LIFE OF THE FACILITY (SECONDARY SETTLEMENT) BE ACHIEVED?
  - CAN A BENEFICIAL CONSTRUCTION ALTERNATIVE BE ACHIEVED?

- ANSWERS
  - YES - ORIGINAL CONSTRUCTION WAS COMPLETED IN 3.5 YEARS. THE AREA OF PROPOSED EXPANSION IS FOUR TIMES SMALLER.
  - YES - WILL REQUIRE THE USE OF PV DRAINS.
  - YES - SURCHARGING CAN LIMIT POST CONSTRUCTION SETTLEMENTS TO <2”.
  - YES - PV DRAINS, GROUND IMPROVEMENT AND SURCHARGING CAN FACILITATE “RAPID” CONSTRUCTION OF ADDITIONAL DREDGE PLACEMENT AREA.

CONCEPTUAL CROSS SECTION - PROVEN



NOTES:

1) ALL SLOPES SHOWN FOR ILLUSTRATION ONLY. ACTUAL SLOPES TO BE DETERMINED DURING DESIGN PHASE.
2) PV DRAINS ARE SHOWN ON THIS DRAWING FOR ILLUSTRATIVE PURPOSES ONLY. ACTUAL PV DRAIN LOCATIONS WILL WILL EXTEND ACROSS THE ENTIRE SITE.
3) VERTICAL SCALE IS EXAGERATED TEN TIMES LARGER THAN HORIZONTAL SCALE.
4) ALL ELEVATIONS ARE REFERENCED TO MEAN LOWER LOW WATER LEVEL (MLLW).
5) OFFSET PER STABILITY CALCULATIONS COMPLETED BY FOWLER ET AL. (1987).

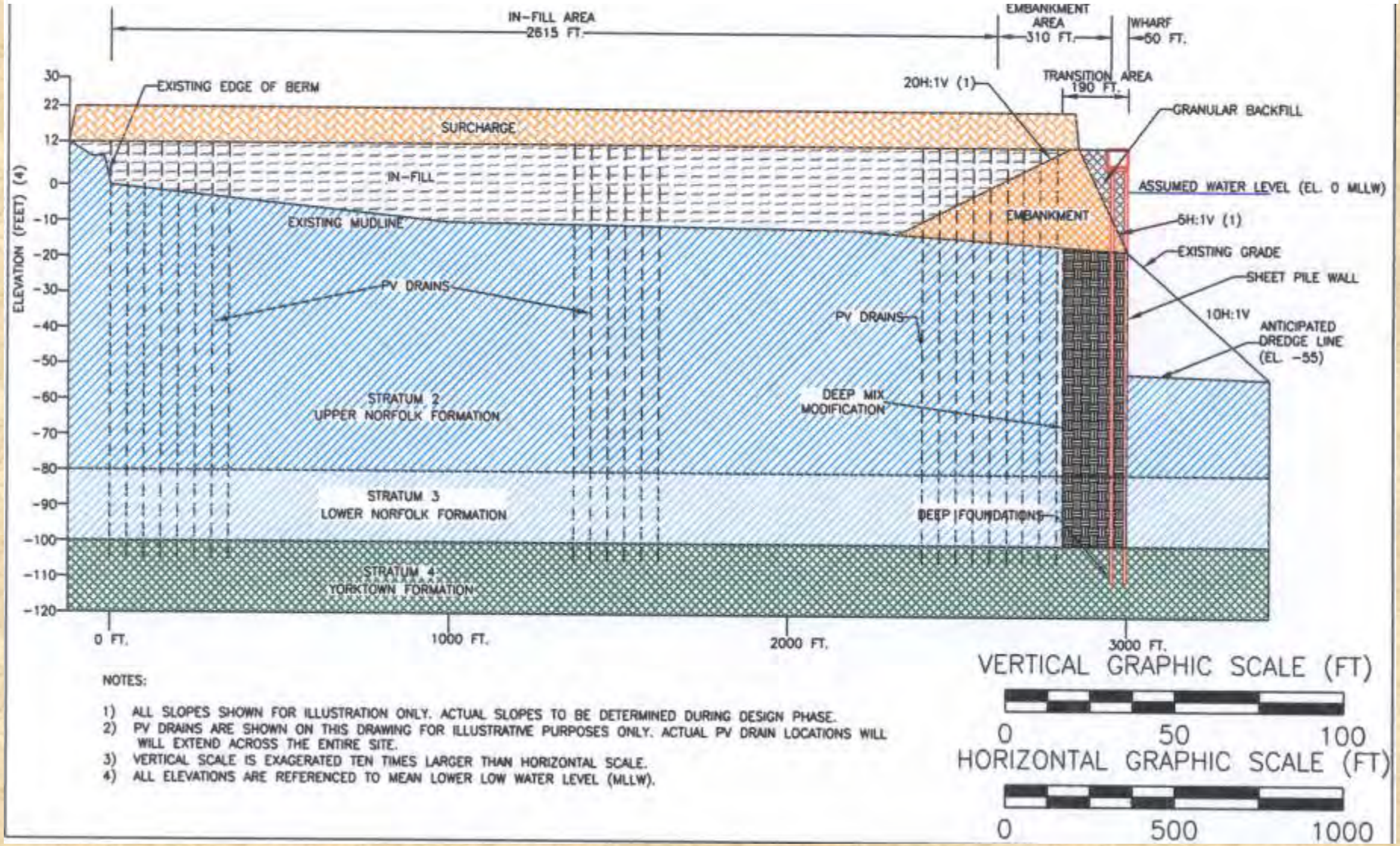
VERTICAL GRAPHIC SCALE (FT)

0 50 100

HORIZONATAL GRAPHIC SCALE (FT)

0 500 1000

CONCEPTUAL CROSS SECTION - INNOVATIVE



COMPARISON OF CONCEPTUAL SECTIONS

- PV DRAINS AND SURCHARGE
  - TOTAL ADDITIONAL MANAGEMENT VOLUME = 13.4 MILLION YD^3
  - ESIMTATED PROBABLE CONSTRUCTION COST= “X” DOLLARS
  - APPROXIMATE COST PER UNIT VOLUME ADDITIONAL MANAGEMENT SPACE = “Y” DOLLARS PER YD^3

- DEEP SOIL MIXING, PV DRAINS, AND SURCHARGE
  - TOTAL ADDITIONAL MANAGEMENT VOLUME = 21.0 MILLION YD^3
  - ESIMTATED PROBABLE CONSTRUCTION COST = 85% “X” DOLLARS
  - APPROXIMATE COST PER UNIT VOLUME ADDITIONAL MANAGEMENT SPACE = 50% “Y” DOLLARS PER YD^3

- CONCLUSION
  - AN INNOVATIVE APPROACH CAN SUBSTANTIALLY INCREASE THE AREA AVAILABLE FOR DREDGE MANAGEMENT BEYOND THAT POSSIBLE WITH TRADITIONAL CONSTRUCTION METHODS.

CONCLUSIONS

- COST OF A DETAILED SUBSURFACE INVESTIGATION PROGRAM WAS LESS THAN 1/10 OF A PERCENT OF AN ESTIMATED CONCEPTUAL COST.

- SUBSURFACE CONDITIONS IN THE VICINITY OF CRANEY ISLAND ARE FAIRLY CONSISTENT AND CAN BE CHARACTERIZED WITH CURRENT EXPLORATION TECHNIQUES.

- USE OF A JACK-UP BARGE, FULLY CASED DRILLING METHODS, AND LARGE DIAMETER SAMPLES ARE PROVEN WAYS TO LIMIT SAMPLE DISTURBANCE.

- THE CPT CAN BE AN EFFECTIVE TOOL FOR RAPIDLY CHARACTERIZING STRATIGRAPHY AND UNDRAINED SHEAR STRENGTH AT CRANEY ISLAND.

- THE CPT CAN BE AN EFFECTIVE TOOL TO DETERMINE % CONSOLIDATION UNDER FILL AREAS.

SUMMARY

- A PROJECT APPROACH CONSISTING OF RESEARCH, FIELD EXPLORATIONS, AND LABORATORY TESTING YIELDED THE DESIRED RESULTS FOR THIS STUDY.

- UTILIZATION OF MULTIPLE EXPLORATION TECHNIQUES RESULTED IN AN EFFICIENT FIELD DATA COLLECTION PROGRAM.

- HIGH QUALITY LABORATORY TESTING IMPROVED CONFIDENCE IN THE RESULTS OF THE FIELD DATA.

- THE SOIL PROPERTIES AND PARAMETERS DETERMINED BY THIS EFFORT ARE CONSISTENT WITH PREVIOUS EFFORTS.

- A BENEFICIAL EASTWARD EXPANSION COULD BE ACHIEVED BY USING AN INNOVATIVE APPROACH.

CHARACTERIZATION OF SOFT CLAY- A CASE STUDY AT CRANEY ISLAND

THANK YOU!

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